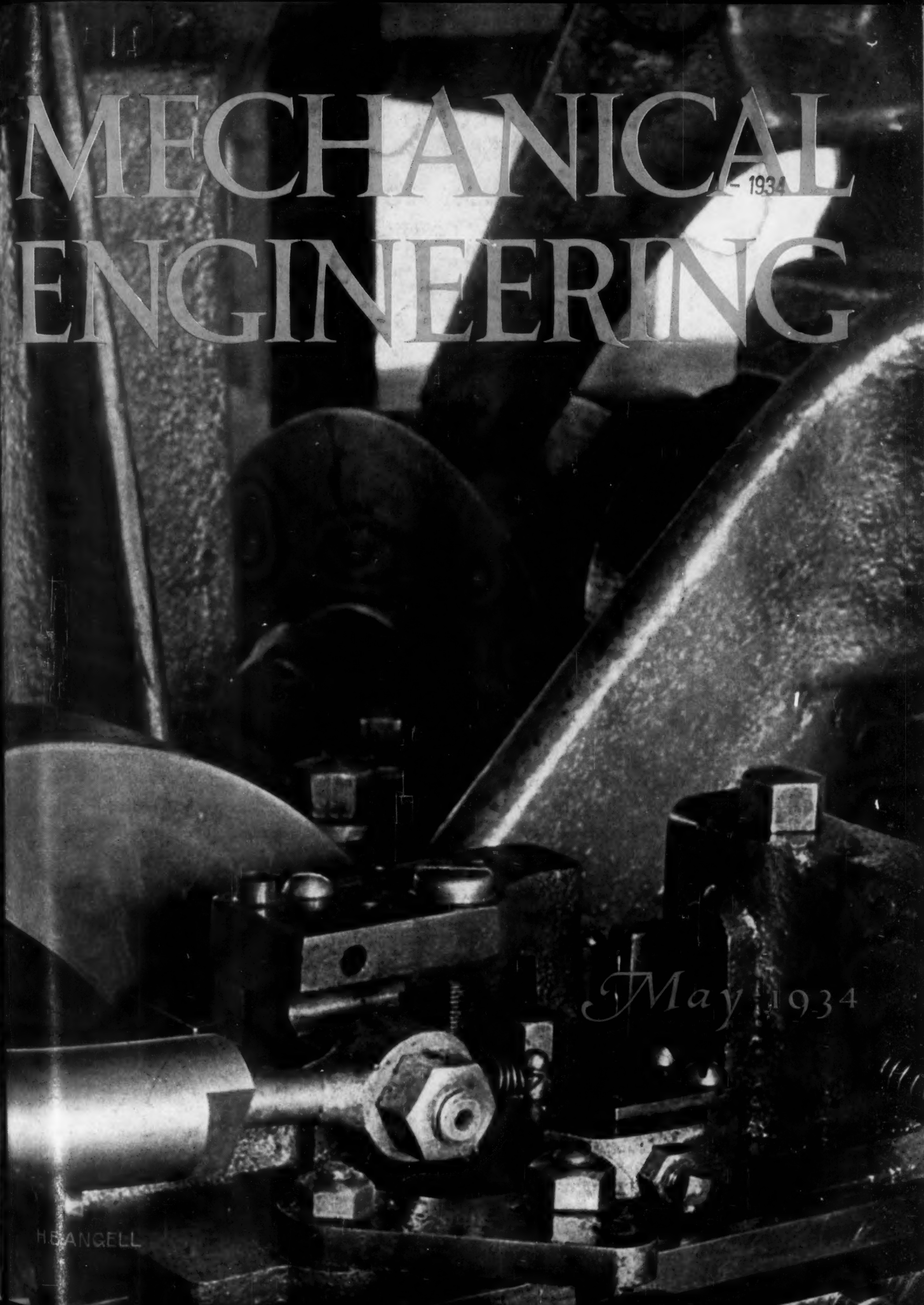

MECHANICAL
- 1934
ENGINEERING
May 1934
H.B.ANGELL

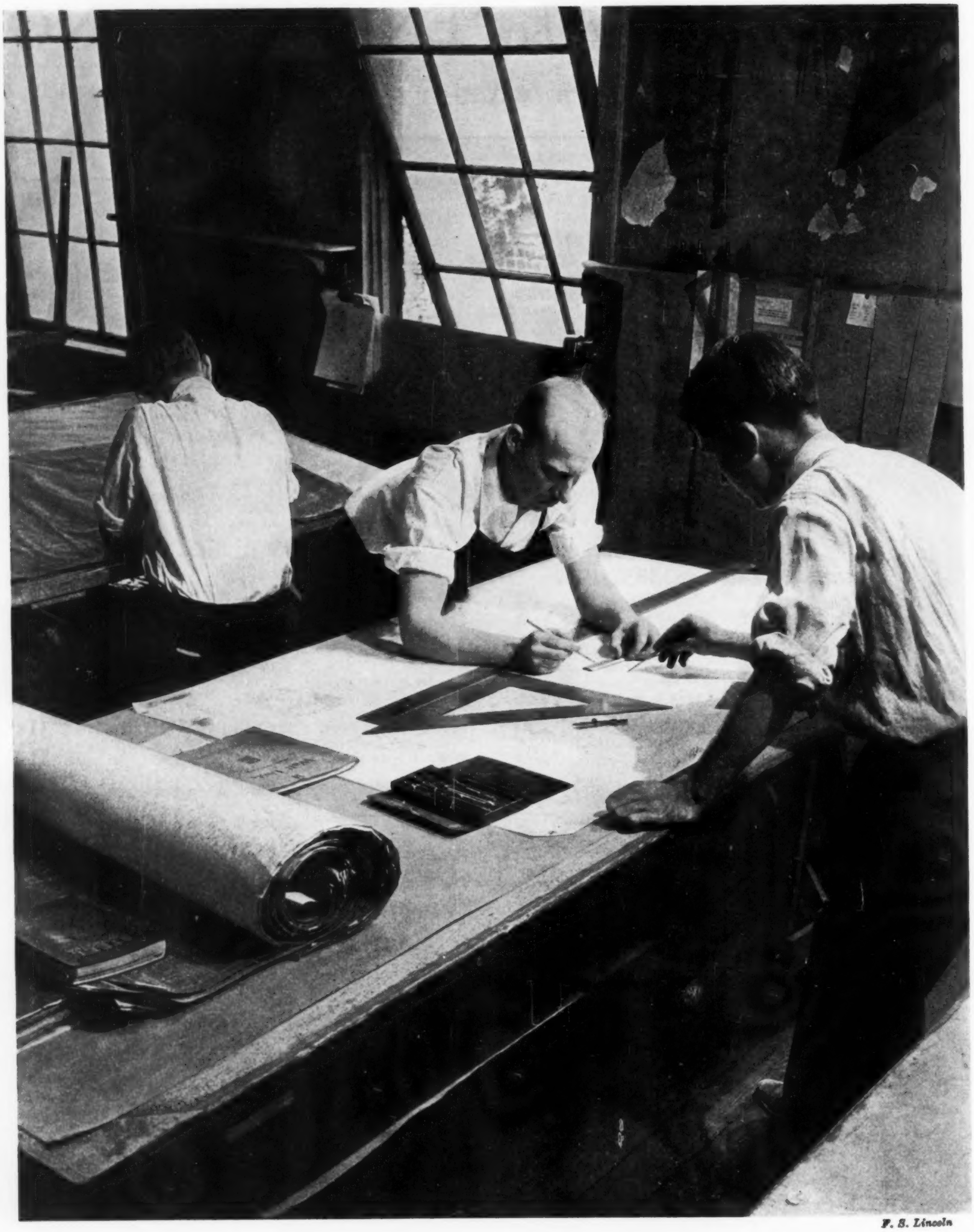
MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 56 NUMBER 5

Contents for May, 1934

Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York, N. Y. Cable address, "Dynamic," New York. Price 60 cents a copy, $5.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage to Canada, 75 cents additional, to foreign countries, $1.50 additional. Changes of address must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address....By-Law: The Society shall not be responsible for statements or opinions advanced in papers or....printed in its publications (B2, Par. 3)....Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879....Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921....



F. S. Lincoln

Planning the Project

The NEW DEAL *and the* ENGINEER

Comments on Some Significant Phases of the Administration's Recovery Program

By WILLIAM D. ENNIS[1]

The time will come—I hope I live to see it—when, while we shall shudder to read of the disasters of these four years, we shall yet smile to remember the hopeless pessimism of a few..... There are better things ahead, better than we have ever known. I believe it, so do you. We have been advised not to sell America short. More important still, just now, while we relieve distress and root out what is bad, we should be determined not to tear down except to build better. It is important not to breed any new race of rats. The only revolution we have to fear is a revolution in the minds of men which makes it impossible to do business together.

After all, engineers are people. I am not going to talk about public works or Muscle Shoals. The major effects of the New Deal on the engineer are those experienced by him in his capacity as a business man; that is, as a man who has to earn a living. The standpoint from which such a man naturally appraises the New Deal is that of its effect on production, or, rather, on productivity or the capacity for production.

To this audience it should be safe to stress the production standpoint. We have been told repeatedly these past few years that goods are useless unless buying power exists. It is equally true that markets are useless without goods. Distribution may have been unscientific and unfair, but we should not kill the goose that lays the golden egg.

The profit motive, that historic mainspring of our American economy, has been weakened. Commerce and piracy always have been incompatible.

"I am speaking of those individuals who have evaded the spirit and purpose of our tax laws, of those high officials of banks or corporations who have grown rich at the expense of their stockholders or the public...." Thirty years ago a great industrialist started a horse-laugh heard round the world when he spoke of the "Christian men to whom God has given the control of the property interests of the country." These modern successors of Mr. George F. Baer exhibit all of his egotism with none of his sense of responsibility. Their time has come. It is time to turn them out.

SOME NEEDED REFORMS

The New Deal has as its sincere objective the correction of such abuses. It aims to be a fairer deal. It is time for at least a new deal when one of the players is caught with five aces.

We are going to have a fairer deal, I think, about income-tax evasions and exemptions. Thus far, the tax laws have put the Capones and Waxey Gordons in jail, but not the larger operators whose nominal activities were more respectable and who were more competently advised. Ponzis are punished, but others escape. These men, by registering losses and forming Canadian corporations, and by other devices, have economized in ways which I hope will be closed to them and all the rest of us in and after 1934.

I wish it were true, but it is not, that this year promised some reform to put a stop to receivership and reorganization scandals. The typical deposit agreement under a reorganization plan for an insolvent corporation is irrevocable; yet the personnel of the managing committee may be changed without the assent of depositors. There is no limitation of committee disbursements or expenses. The committee need not treat all security holders alike. Its members may trade with themselves; may be principal and agent in the one transaction. The deposit agreement may be amended without the depositor's consent. Committee members have a highly limited responsibility and almost no legal liability. Committees are self-constituted; often, of the very men responsible for the bad situation. Yet if a dissatisfied depositor seeks to associate himself with others for remedial action, he is denied access to a list of security holders.

THE GUARANTEED-MORTGAGE DEBACLE

Equally bad, and for the moment equally hopeless, is the situation in and around New York, and probably elsewhere, with respect to guaranteed mortgages. For many years these mortgages or participation certificates were regarded as the preeminently desirable security for investments of widows and orphans for whom they were the sole support. Banks recommended them. The relatively high rate of return—5 or $5^1/_2$ per cent—was explained to be due to the fact that they were not immediately and automatically liquid. They regularly sold within a fraction of a per cent of their face value.

Today, none of these companies is making good on its guarantees. All are "in rehabilitation," a new phrase

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An address delivered at the Annual Banquet of the Providence Engineering Society, Providence, R. I., February 15, 1934.

which we have coined to replace a shorter and uglier word. And we are learning gradually that for years guarantees have been far in excess of a safe ratio to reserves, that nominal reserves have been encumbered, that statements have included at full original value the principal and delinquencies of unmarketable mortgages, and that almost up to the date of action by the state, dividends have nevertheless been paid to stockholders, to the injury of certificate holders. And it appears that the responsible state officials have known of these facts all along. They have neither corrected them nor informed the investing public. These certificates are selling currently at 25 to 50 per cent of their face value. Income has been cut correspondingly.

The rebuttal is that the companies were embarrassed by a sudden and severe decline in values and prices. It is a familiar defense. "He would have made good if he hadn't been caught on the wrong side of the market."

There is some prospect of reform in corporation finance. Stock exchanges are to be regulated. The Fletcher bill for this purpose contains unexpected provisions. It is drastic and even revolutionary. In some respects it should perhaps be changed. But it furnishes the basis for a good law. We are going to have more adequate and competent financial statements. There will be closer scrutiny of control exercised by organized small minorities. Holding companies are under fire. Some of our utilities are probably in for a spanking. Strangely enough, it was not rates which brought this about, acrimonious as that subject has been. It was scandalous high finance which did it. I don't believe the honest utilities are going to suffer much.

Title I of the National Recovery Act promises (in some respects) a better deal for business. Trade associations are strengthened and we shall have much better cost accounting—both logical developments from the trade-practise conferences of preceding administrations.

THE SECURITIES ACT

Then there is the Securities Act of 1933. This has the purpose (modest and justifiable enough) of making it possible for a prospective investor to judge as to the merit of a security offered. He may need to be an expert to do so; but in the past not even an expert could. There must be a disclosure of commissions and fees paid underwriters and others. Why not? Penalties are provided for false statements. Again, why not? Even unintentional misstatements are to be punished; a good way to make men careful. After all, these promoters are asking for your money and mine. If it is true that those issuing the prospectus are to be responsible for statements made by others, they will choose those others—accountants and engineers—carefully. Why shouldn't they? They choose the experts, not we. We merely read what the experts say. It is asserted that the act will "make borrowers hesitate." I hope so. That will be a good thing for the country. And it is said that it will be "difficult to get good men to be directors." If by good men is meant men who seek to avoid accountability for their acts and statements, I hope it will be. It should be impossible.

Some have claimed that the Securities Act "will make existing methods of marketing securities untenable." That is a consummation devoutly to be wished. The objections to the act seem to me mainly the howls of men for whom chicanery is now to be made difficult.

The act is the nation's rejoinder to that investment banker who nonchalantly admitted three or four years ago, "We are merchants," a phrase as insulting to the merchant class as it is contemptuous toward the investing public.

THE BANKING ACT

Finally, in this category is the Banking Act of 1933. Few activities have gone as far in silly cut-throat competition as banking.

The new act prohibits Federal Reserve member banks from paying interest on demand deposits, something which they never should have done. With a view to the restriction of speculation, some additional control has been provided for loans, particularly those on collateral security. The act provides for the substantial separation of commercial from investment banking, although unfortunately leaving some loopholes for interlocks and participations. It permits a certain amount of branch banking, with the object of discouraging weak and amateur banks in suburban and perhaps rural districts. All of these steps seem to be progressive, even though inadequate.

The most important provisions of the act are those relating to the guaranty of bank deposits. Today the man who has $2500 or less in any qualified eligible bank (including about two-thirds of all the banks there are, and every Federal Reserve member bank) is protected by a government-backed pool. If he has more than $2500 he can be fully protected by dividing it between eligible banks. The plan safeguards about 97 per cent of the depositors in eligible banks. Assessments against solvent banks are limited. After July 1 of this year, all deposits will be guaranteed, but the guarantee will be less than complete on deposits exceeding $10,000. Assessments will then be unlimited. The present temporary guaranty plan is to be preferred, I believe, to the permanent plan. It now looks as if it might be continued while the so-called permanent plan is reexamined.

Both plans have been vigorously opposed. All state guaranty plans (there have been eight of them) have failed. Other countries have sound banking (something we have never achieved) without guarantees.

Nevertheless, the thing is going to be tried. Its purpose is sound banking. Our bankers were given a chance to clean house and they didn't do the job. Bank failures have not been confined to rural or remote regions. There has been a conspicuous lack of such high professional standards as have prevailed, for example, in Canada. (New England has had superexcellent banking as compared with some other sections of the country.)

Much of the fault lies at the government's own doorstep. We have in this country fifty different sets of banking

laws. Bank supervision by government has been inadequate and sometimes incompetent or indecisive. Government supervision, and banking itself, both need reform. Government can stop bad banking. Good bankers can do very little outside of their own institutions. Our national record of bank failures has been intolerable even during prosperity. Just about one-third of all the banks of this country have suspended payments since 1921.

It is true that sound banking is what we are after, and that the guaranty will do harm (vast harm) instead of good unless it leads to sound banking. But for the time being there is no other adequate protection for the small depositor in most of our states. Let us hope, however, that the deposit guaranty will not be used to buttress up weak banks which ought to fail.

Thus we are trying to turn the rascals out; to safeguard ourselves against financial buccaneers. I hope we shall not burn down the barn in order to get rid of the rats. (I approach this subject with the feeling that it is on the whole a pretty good old barn. At any rate, I see no real plan for a new one.)

SOME UNCERTAINTIES IN THE NEW DEAL

The harm done by the rats was not so much the direct damage, but arose from the impairment of confidence which they caused. And this is the standpoint from which we must estimate the constructive and positive features of the New Deal. This is the second part of our inquiry. We must try to appraise its effect on public confidence, on the will to keep going. "The fundamental condition of recovery is one in which individual enterprise will again become active."

Code restrictions of "unfair competition" are (I believe) going to make trouble. Prices must not be below cost. Whose cost? It was natural to assume the individual producer's cost. Thus the efficient producer could undersell the less efficient, sound competition would continue, and progress would be possible. This seemed the only rational view, and various interpretations and rulings at first supported it. But now we are told, authoritatively, that allowing one man to sell a product at 90 cents, his cost, while requiring a higher-cost employer to charge $1 for the same article, would have the effect of "legislating a competitive advantage." This seems to leave it in doubt whether the price is to be 90 cents or a dollar, but clearly it is to be the same for both producers.

Again, prices must not be below cost; but what cost? If total cost is meant, many justifiable trade practises (like seasonal clearances of stocks) must be given up. It will be hard to get started with the marketing of new products. Hence nearly all (perhaps all) codes contemplate certain exceptions to the general rule. There is some doubt as to whether it is practicable to hold selling price generally much above the level merely of out-of-pocket cost, or what engineers call direct cost. For if a producer has surplus capacity and can in one way or another classify his sales, he will sell part of his output at any price above out-of-pocket costs rather than not sell it. This is what economic theorists call class-pricing. It is advantageous to the producer, to the consumer who pays the cut price, and also, generally, to the consumer who pays the full price. Prices of electricity and of railroad freight transportation are influenced according to this principle. It leads to something that may be called socialistic—to a price system that is based on ability to pay. But if it is profitable, we can stand that.

I now approach one part of my topic regretfully. Some one has warned us, "Do your cussing under your breath and pull a strong oar." I think there has been a considerable measure of impairment of confidence resulting from acts by government (Federal, state, local). Let us make every allowance. Some of the steps to be mentioned were honestly taken to avoid worse things. Some may have been necessary evils. One step has led to another. This is a period of distress and therefore of emergency. After any disaster, repair bills have to be paid. Much of what may be questioned in Federal action was done, or at least begun, in the previous administration. But after all of these stipulations, it seems to me to be the fact that in some ways business enterprise is being retarded rather than encouraged, and recovery checked. The handicaps may be in part unavoidable, but we must recognize them as handicaps. This is not to deny that good has been accomplished. Between three and four million men put at work within less than a year is a magnificent performance. But we are now looking at the other side.

Thus, since the middle of 1932 our largest financial institutions have been issuing statements in which holdings of securities are deliberately and seriously overvalued. This is being done with government sanction. We are blinding ourselves to facts.

In bank reorganizations under government auspices, the protection expected from double liability has not materialized, and depositors have had to become stockholders.

In many states, mortgages are now unenforceable. Even where taxes and interest are both in arrears, creditors are unable to protect themselves. Home Loan bonds which they have been urged to accept are selling at a discount. No building program can get started.

THE DANGER OF INFLATION

Then there is the question of inflation. A majority of monetary economists, in my judgment, and a probably smaller, less outspoken, majority of business men, oppose it. Others distrust it without pretending to understand it. Organized labor is officially adverse. There are on the other hand several proponent groups: those interested in silver; many owners of mortgaged farms and homes; those advocating price-stabilization at the 1926 level; and, perhaps most influential, some of the large group of those who find themselves loaded up with second (and lower) grade securities which they hope to sell at higher prices.

As I count them, we have had during the past two or three years about a dozen inflationary proposals and

authorizations (using the term "inflation" in the broad sense) and have tried out all but one or two of them.

Three of the inflationary measures, begun under the previous administration, were permissive and calculated to make it possible for banks to issue more money. They were: purchases of government securities by the Federal Reserve system, enlarging the list of government bonds eligible as backing for national bank notes, and making government bonds acceptable in place of commercial paper as security for Federal Reserve note issues. The last two measures might have added about $3^1/_2$ billions to our paper currency. They actually added only about half a billion. The explanation is the same as that for the failure (as a method of monetary expansion) of the bond purchase plan. Under that plan the Federal Reserve system bought about 581 millions in government securities in 1933. Member bank reserves increased 333 millions as a result; but loans and investments of reporting member banks decreased over 2000 millions. The new money was not created, because there was no acceptable market for it. Similarly, with respect to the issue last March of Federal Reserve Bank notes under the Emergency Banking Act. No one can estimate what the limit of such issues might be. A suggested amount was 10 billion dollars. Actual issues to date have been slightly over 200 millions and the amount outstanding has recently begun to decline.

Government itself has as yet taken no step toward forcing any large increase in paper-money supply. The President has the power to issue three billions in greenbacks. It is a power never before delegated in our history. There is the restriction (due to the suggestion of an engineer) that this money can be issued only to retire government debt. The power of Congress to issue paper money is unlimited.

A small forced inflation is implied in the recent silver-purchase edict. The Government is to buy probably at least $24^1/_2$ million ounces of silver yearly for four years at $64^1/_2$ cents per ounce, the previous market price having been around 40 cents. This makes a present of about 20 million dollars to our silver producers. It also confers a benefit on foreign silver producers and owners because it has caused an advance in world prices of silver. At such world prices, the metal value in and back of our new silver dollar was only about 70 cents. Still more recent legislation makes it only 35 cents, if the intent of the legislation is carried out. This procedure will add probably at least 16 million dollars yearly for four years to our monetary supply; in all, less than one per cent. The Pittman amendment to the Gold Reserve Act of two weeks ago may double this. But all this is comparatively unimportant. We have long had about 800 millions of overvalued silver money and it has done no particular harm.

THE ADMINISTRATION'S GOLD POLICY

The thing that disturbs many of us more than all that has preceded is the policy of the Administration with respect to gold. This began with a domestic embargo. The ownership of gold was made illegal. (But the anti-hoarding campaign left over half a billion dollars of gold and gold certificates still unaccounted for.) The Government then, of course, ceased to redeem its currency in gold. Similarly, the promised payment of government debts in gold was discontinued, and private borrowers were relieved of their corresponding obligations. This had international effects. Yet even after these steps had been taken, the Government continued promising to pay gold. Even today, the face of our Federal Reserve notes carries a promise to redeem in gold on demand; a promise which is not being kept. It is now no longer to be made. The price of gold was then bid up until our dollar stood at a 39 per cent discount. The avowed purpose was to restore the 1926 (?) price level. But average wholesale prices have advanced only about one-third the distance to this level, and much of that advance took place before gold buying began.

Then, two weeks ago, the weight of gold in the dollar was reduced from 23.22 grains to 13.71 grains and the Treasury took over the $3^1/_2$ billions of Federal Reserve gold, relabeling it 6 billion dollars. "Literally out of thin air does a profit appear" of $2^1/_2$ billions, and Prof. Irving Fisher computes that we are actually reducing our national debt. This sets the stage for an inflation which is hailed by its proponents as "uncounteractable by Federal Reserve action."

INCREASING COSTS OF GOVERNMENT

Not always thought of as inflation, although it should be, is increasing expenditure by the Government. The Federal budget for the year ending June 30, 1934, involves disbursements of $10^1/_2$ billion dollars. Deducting estimated revenue, the deficit is 7.3 billion. This is the increase in national debt in one year. It is three times the increase which occurred during the whole Civil War. The rate of increase has been exceeded in our history only over the period 1917–1919. About ten billion dollars must be borrowed this year to cover the deficit and to provide for certain debt maturities. There are some assets, uncertain in value, offsetting these figures; but no one knows how much will be repaid of R.F.C. loans and of advances for self-liquidating public works. Aside from such recoveries, the 7.3 billion deficit represents money which will be contributed by taxpayers to the distressed groups in our population, plus a small amount for possibly valuable though not self-liquidating public works, plus certain inevitable costs and wastes.

If the costs of local and state government are added, government is disbursing this year money equivalent to more than one-third the total national income of 1933; about 40 per cent of the aggregate income of 125,000,000 people.

Of actual currency inflation we have had little. Of measures which seem to threaten it we have had plenty. We are having more than a new deal. It is a new game; or, rather, it is changing the rules while the game is in progress.

(*Continued on page 304*)

The ENGINEER *as an* INVENTOR

A Statistical Study Based on "Who's Who in Engineering"

By BURKE SMITH[1]

THE ART of inventing is closely allied to that of engineering. It is known that many engineers are prolific inventors and many inventors may properly be classified as engineers. Rossman[2] found as a result of a questionnaire that 59.8 per cent of the inventors whom he studied were engineers. Few data have been published, however, on the inventing performance of engineers as a group. A statistical study of the engineer as an inventor is therefore of some interest, especially to those who are concerned with the training of the coming generation of engineers.

In the past, no attempt has been made by engineering schools to train their graduates in the art of inventing, and it is not known what effect present methods of academic training have on students who possess an inventive turn of mind. There are some who believe that the formal training which a young engineer now receives in our colleges and universities has the effect of suppressing whatever innate ability as an inventor he may happen to have. What is needed is definite information in regard to questions such as the following: How do college-trained engineers compare in inventiveness with those who are not so trained? Does college training tend to stifle or suppress native inventive ability? What effect has post-graduate study, and in particular the attainment of the Ph.D. degree, on the inventing performance of graduate engineers? The results of the study described in this paper throw some light on these questions.

The statistical data for the study were obtained from the 1931 edition of "Who's Who in Engineering." This volume contains brief biographies of some 10,800 engineers, all of whom were asked by the editors to list any inventions which they had made. The names in this edition are stated to have been chosen from the following groups:

(1) Engineers of outstanding and acknowledged professional eminence.

(2) Engineers of at least 10 years of active practise, at least 5 years of which have been in responsible charge of important engineering work.

(3) Teachers of engineering subjects in colleges or schools of accepted standing who have taught such subjects for at least 10 years, at least 5 years of which have been in responsible charge of a major engineering course in such college or school.

In view of these qualifications it may be assumed that the results here given apply to successful engineers, rather than to the rank and file of the profession. The names which were used were selected from "Who's Who in Engineering" by choosing all those occurring on a certain definite number of pages out of each 100 throughout the book. By this method of selection a random choice was secured. The names were copied on punched cards with such educational and personnel data as were pertinent to the study. The cards were then sorted mechanically. From a study of 5384 names obtained in this way, a total of 959 names were found of engineers who state that they are inventors. On this basis, 17.8 per cent of the engineers listed in "Who's Who in Engineering" are inventors.

Sixty per cent of the inventors give a list of the inventions which they have made, or state the number. The remainder do not give definite information as to the number of their inventions. About 45 per cent of the inventors state that their inventions are patented. It is probable that a much larger percentage than this patented their inventions, since the individuals were not asked specifically whether their inventions are patented or not. Inventions rather than patents were taken as the basis for the statistics of this study, except where otherwise stated.

In what follows, the term "inventiveness" as applied to a group will mean the percentage of inventors in the group.

INVENTIVENESS OF DIFFERENT KINDS OF ENGINEERS

It was possible to classify many names by kinds of engineering. From the stated occupations, 2408 names were classified into five broad engineering divisions and the percentage of inventors was noted for each division as follows: Mechanical, 30.5 per cent; chemical, 29.7 per cent; electrical, 21.2 per cent; mining and metallurgical, 14.2 per cent; and civil, 5.9 per cent. As might be expected, the mechanical engineers show the highest percentage of inventors, but the chemical engineers are also very active.

It was also possible to classify the names into certain functional groups. The inventing performance of two such groups, namely, executives and teachers, will be noted here. The executive group includes only those listed as presidents or vice-presidents. It was found that 26.2 per cent of the executives are inventors as compared to 11.5 per cent of the teachers. The number of inventions per inventor averages 8.0 for the executive group and 4.7 for the teachers, while the proportion of inventors who produced more than five inventions each averages 14.3 per cent for the executive group and 11.6 per cent for the teachers. The executives

[1] Transmission Engineer, Illinois Bell Telephone Co., Chicago, Ill.

[2] Joseph Rossman, "Psychology of the Inventor," p. 148.

are thus a rather highly inventive group while the teachers are below the average of the entire list of names studied, and are less than one-half as inventive as the executives.

EDUCATION AND INVENTING PERFORMANCE

In order to study possible correlations between education and inventing performance the names chosen were divided into three groups as follows: Group 1—All those who, according to the record, have had no formal training of collegiate grade. Of this group 25.0 per cent were found to be inventors, with an average of 8.5 inventions per inventor, while 17.9 per cent of the inventors produced more than five inventions each. Group 2—Those who have had some college training but, as far as the record shows, did not graduate. Of this group 21.6 per cent are inventors with an average of 11.4 inventions per inventor, and 21.6 per cent of the inventors have more than five inventions each to their credit. Group 3—All those who are listed as college graduates. Of this group 16.6 per cent are inventors, with an average of 10.6 inventions per inventor. Eighteen per cent of the inventors have more than five inventions each to their credit. It will be noted that while the percentage of inventors who have produced more than five inventions each is the same among the college graduates as among those who have had no college training, the latter group is 50 per cent higher in inventiveness than the college-graduate group. Those who have had some college training but did not graduate are 30 per cent higher in inventiveness than those who graduated.

In comparing these figures, allowance must be made for age. The median age of those who have had no college training was found to be $50^1/_2$ years, while the median age of the college graduates is $46^1/_2$ years. The older group should have a slightly higher percentage of inventors, since the number of inventors increases with the age of the group. Furthermore, the occupations have a bearing on the inventiveness of a group. Group 1 has a higher percentage of executives than Group 3, while the latter group has a higher percentage of teachers, there being practically no teachers among those who have had no college training. As already noted, the percentage of inventors among executives is more than twice that among teachers. Other unknown factors make a direct comparison of the inventiveness of these two groups difficult. It is not known, for example, to what extent those with a natural aptitude for inventing enter college. If a young man finds that he is able to produce practical, successful inventions, the most tempting path toward the attainment of professional status as an engineer may appear to him to be the development of his talents in the school of experience rather than the continuation of his academic training. Nevertheless, the fact that the group with no college training is 50 per cent higher in inventiveness than the college-graduate group calls for further investigation. If the educational methods which have been in vogue during the past few decades and intense application to studies on the part of individual students have tended to inhibit or suppress originality and other traits which the successful inventor must have, the group of engineers who made a superior scholarship record while in college would be expected to contain a smaller percentage of inventors than the total of all college graduates. It is possible to select a superior-scholarship group by choosing those graduates who are members of Phi Beta Kappa or Tau Beta Pi, since these societies elect to membership only those who stand in the upper one-quarter to one-eighth of their class in scholarship, and are representative of undergraduate honor societies in institutions of collegiate grade. A study was made of these two groups, omitting those who are Ph.D.'s, since both the percentages of inventors and membership in honor societies are relatively high among Ph.D.'s. On this basis the inventiveness of members of Phi Beta Kappa (a group of 93 names) was found to be 18.3 per cent and of members of Tau Beta Pi (351 names) 16.5 per cent, as compared to a general average for all graduates except Ph.D.'s of 16.1 per cent. From these data there does not appear to be any marked difference between the inventiveness of graduates with superior scholarship standing and that of the general average of graduates. The slightly higher inventiveness of members of Phi Beta Kappa compared with the average of all graduates is hardly significant, due to the small number of names in the Phi Beta Kappa group.

Membership in the society of Sigma Xi is awarded primarily on the basis of promise or actual achievement of research. From a study of 312 members of this society, omitting Ph.D.'s, it was found that the inventiveness of this group is 22.4 per cent, which suggests that membership in Sigma Xi may, on the average, indicate a certain degree of latent inventive ability.

In choosing the above groups, the names of all members of the three societies in the first 50 of each 100 pages throughout the book were selected, except that the names of all those who are members of more than one of the three societies were omitted. For example, those who are members of both Tau Beta Pi and Sigma Xi were not included in either group.

To determine whether there is any correlation between post-graduate education and inventiveness, a group of 2904 graduates was divided into inventors and non-inventors. It was found that 30.6 per cent of the inventors and 29.7 per cent of the non-inventors had taken post-graduate work. This indicates that post-graduate training is of no significance as a factor in the performance of inventors. However, 9.5 per cent of the inventors as compared to 6.3 per cent of the non-inventors have Ph.D. degrees, indicating that there is a higher percentage of Ph.D.'s among the inventors.

The Ph.D.'s represent a group of individuals who have had the most intensive educational training and it is, therefore, of interest to study them as a separate group. Most Ph.D. degrees awarded to individuals listed in "Who's Who in Engineering" were obtained in the field of physical science rather than in engineering,

since the granting of this degree in engineering is comparatively recent. Of 591 Ph.D.'s who were studied, 24.6 per cent are inventors, the average number of inventions per inventor being 26.5. Of those who are inventors, 24.3 per cent produced more than five inventions each. One Ph.D. has made 1000 inventions.

It is interesting to compare the Ph.D.'s with those engineers who have had no formal training of collegiate grade, listed as Group 1. The inventiveness of these two groups is the same, the average number of inventions per inventor being three times as great, however, in the Ph.D. group as in Group 1. From these data we may conclude that as inventors the engineers who have had the most intensive academic training and those who have had no formal training of collegiate grade are very nearly on a par. It may be said that the Ph.D.'s give a slightly better account of themselves than those who did not go to college since they are productive of a greater number of inventions.

Summarizing the results obtained, the data indicate that among graduate engineers the degree of college training, as measured by the number of years of such training and by scholastic standing while in college, has little to do with inventing performance. A college-trained engineer-inventor may or may not have been studious while in college and he may or may not have taken graduate work. On the other hand, from the inventing performance of Ph.D.'s and members of Sigma Xi it appears that those engineers who, during their college years, showed more originality of mind than their fellows and were able to do research work are, as a group, more inventive than the average graduate engineer. It is not known to what extent the art of inventing can be taught. But since Ph.D.'s and the non-college-trained group are equal in inventiveness and since the Ph.D.'s represent a group which has undergone the most intensive and prolonged academic training, one is not justified in concluding from these data that a college education tends to stifle or suppress native inventive ability.[3] The greater inventiveness of those who have had no college education as compared to that of college graduates may be due in part to a process of natural selection.

PATENTING PERFORMANCE OF ENGINEERS

As already noted, 45 per cent of the inventors listed in "Who's Who in Engineering" state that their inventions are patented. A study of the patenting performance of engineers is of some interest in comparison with figures on patenting performance published by others. In the first 50 pages of each 100 throughout "Who's Who in Engineering" there are 426 names of engineers who state that their inventions are patented; 193, or 45 per cent, state that they have been granted "several" patents without naming the exact number; while 17 per cent mention only one patent each. Of the patentees who give the number of patents which they have obtained, 35.2 per cent hold more than five patents each. Of the entire number of patentees, 83 per cent state that they hold more than one patent each. The average number of patents per patentee is 18.2. Carr[4] has reported the results of a study of 1000 patentees chosen at random from the U. S. Patent Office list. He found that 55.2 per cent of the patentees whom he studied hold only one patent each, while 13.0 per cent hold more than five patents each. Comparing these figures with the above, it is evident that the patentees listed in "Who's Who in Engineering" are much more productive than those studied by Carr. The percentage of patentees who hold more than five patents each is almost three times as great in the engineering group as in Carr's group.

SUMMARY AND CONCLUSIONS

(1) Of the engineers listed in "Who's Who in Engineering," 17.8 per cent are inventors. The mechanical engineers show the highest percentage of inventors (30.5 per cent) with the chemical engineers a close second (29.7 per cent). The inventiveness of executives, i.e., those who are listed as presidents or vice-presidents, is high (26.2 per cent), while that of teachers (11.5 per cent) is below the general average.

(2) Arranging the names in "Who's Who in Engineering" in three groups according to the degree of education, it is found that the inventiveness of those who have had no college training is about 50 per cent higher than that of the college graduates, while the inventiveness of those who have had some such training but did not graduate is about 30 per cent higher than that of the college-graduate group.

These figures do not give a true measure of the effect of academic training on inventiveness on account of a number of unknown factors.

(3) A record of superior scholarship or post-graduate training has little to do with the inventiveness of graduate engineers.

(4) Inventiveness of both Ph.D.'s and members of Sigma Xi is high compared to the general average of engineers. The Ph.D.'s are equal in inventiveness to those who have had no college training. The average productiveness of inventions by Ph.D.'s who are inventors is three times as great as that of the non-college-trained inventors.

(5) The conclusion that a college education in itself has any effect on the inventing performance of engineers is not warranted from the results of this study.

(6) The patenting performance of engineers whose names are listed in "Who's Who in Engineering" indicates that engineers who are patentees are high in productivity of patents as compared to the average of patentees listed in the U. S. Patent Office. The percentage of those who hold more than five patents each is almost three times as great in the engineering group here studied as in the group of patentees studied by Carr, whose names were chosen at random from the U. S. Patent Office list.

[3] In this connection see Joseph Rossman, "Do Engineers Invent?" *Technology Review*, December, 1931.

[4] L. J. Carr, "Patenting Performance of 1000 Inventors During 10 Years," *American Journal of Sociology*, January, 1932.

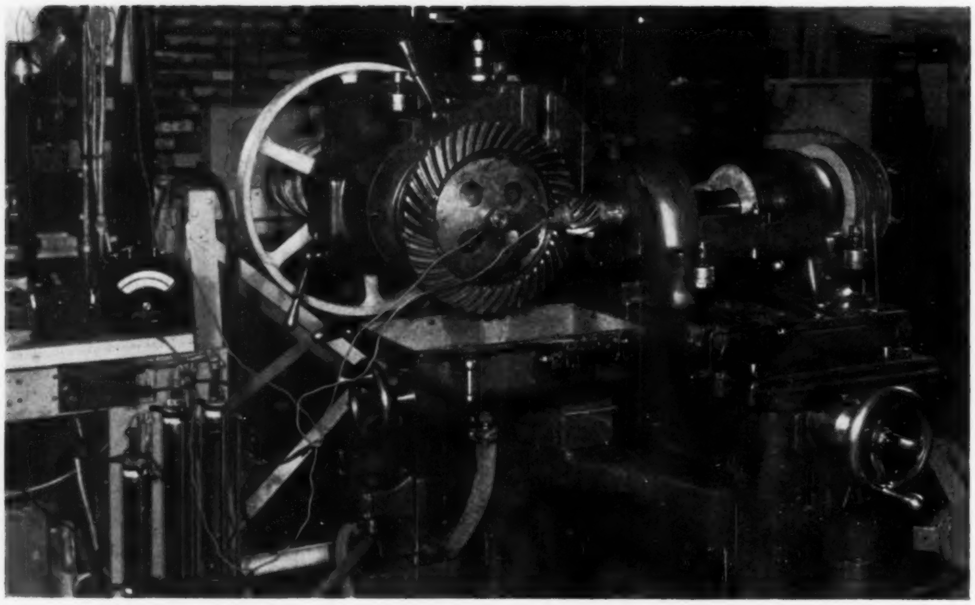

FIG. 1 SET-UP FOR MEASURING INSTANTANEOUS CONTACTS

Measurements of Instantaneous TOOTH CONTACTS *in Spiral Bevel Gearing*

By E. J. ABBOTT[1] and F. A. FIRESTONE[2]

UP TO THE present time practically nothing has been known about the instantaneous tooth contacts in spiral bevel gears. It is common practise to paint gears with red lead or similar material and to run them together to determine the total wiped area or "tooth bearing," but this procedure gives no information concerning the size, shape, and location of the contact areas during the various parts of a tooth engagement. Neither does it indicate the number of teeth in contact at any given time, nor how the load is shared between the contacting teeth. This information requires a knowledge of the instantaneous tooth contacts, and is fundamental to the strength, life, and lubrication requirements of the gears.

Instantaneous contacts in spur gears can be studied optically, but the curvature which gives spiral or helical gears their desirable qualities makes this method inapplicable to them. Studies of the end portions of the teeth are of little practical value on account of the common practise of modifying both the profile and the face of the teeth slightly to bring the contact area toward the center of the tooth and thus allow for greater adjustment.

The computation of the contact of spiral bevel gear teeth is complicated, and one is never certain of the effects of peculiarities of manufacture and of the slight modifications already mentioned. There is also much to be learned concerning the effects of wearing in and deflection under load on the instantaneous contacts. Consequently, there has been a great need for experimental methods of determining the number of teeth in contact at all times, just when each tooth enters and leaves, and the location of the instantaneous area of contact of each tooth during the tooth-engagement cycle. This paper describes the first experimental method of making such determinations which has come to the authors' attention.

With this arrangement standard gears can ordinarily be used without special machining or without damage to the gears. Regular mountings can be used without the need of insulating bearings or similar special parts. All of the measurements described here were made on the ordinary Gleason test stand shown in Fig. 1, but there appears to be no reason why they could not as well be made on actual axle assemblies, either new or after they had been in service in cars. The method should apply equally well to worm or other types of gearing. This development was made in the Physics Laboratories of the University of Michigan in connection with an engineering research project for the Timken-Detroit Axle Company who sponsored and supported the project and with whose permission the material which forms the basis of this paper is presented.

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[2] Assistant Professor of Physics, University of Michigan.

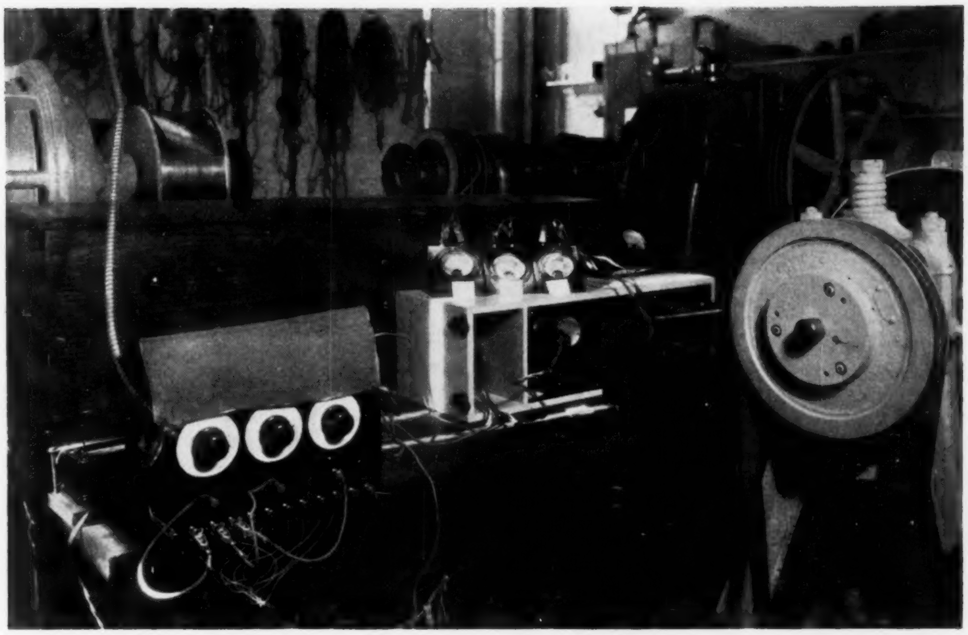


FIG. 2 TERMINAL BOARD AND INDICATOR METERS USED IN INSTANTANEOUS CONTACT MEASUREMENTS

The method devised for measuring instantaneous contacts is very simple and consists of two complementary sets of data, one photographic and the other electrical.

METHOD

Photographic Record. The first of the two sets of data is essentially visual although photographs were made to obtain a permanent record for comparison and study. A thin coat of paint was placed on the pinion teeth to be studied. Torque was then placed on the gear set so that the opposite sides of the teeth were brought in contact, i.e., if the paint was on the "drive" side of the teeth, the "coast" side was held in contact. The gears were then turned until the pinion was in the desired angular position as indicated by a protractor mounted on the pinion shaft. The pinion was then locked in this position by a suitable clamp, which in our case was placed around the pulley just behind the protractor in Fig. 1. Next, the torque on the ring gear was reversed so that the "drive" sides of the teeth were brought into contact with the desired load. This operation transferred a small amount of paint from the pinion teeth to the gear teeth at the points of contact. The torque was then reversed and the teeth turned out of mesh to be observed and photographed. The process was repeated at successive angular positions of the pinion until the entire contact cycle was covered. In this way it was possible to determine the locations of the instantaneous areas of contact during all parts of the cycle of tooth contact.

Electrical Measurements. The electrical measurements were used to determine the number of teeth in contact, just when each tooth entered and left, and approximately how the load was shared between the contacting teeth. An electric current of about 10 amp, 60 cycles, was passed through the gears by contacts made at the center of the ring gear and the center of the pinion shaft as shown in Fig. 1. Measurements showed that about 90 per cent of this current passed from one gear to the other through the contacting teeth and the remainder by the parallel path through the shafts, bearings, and frame of the stand. The latter current was quite constant, and since it did not affect the readings in the least no attempt was made to insulate against it.

In order to determine which of the contacting teeth were carrying the current, a small coil was placed around each pinion tooth in the clearance space at the root. When a tooth made contact, current began to flow through it and a voltage was generated in the coil on that tooth. The leads from these coils were brought out through the cable extending vertically above the pinion in Fig. 1 and carried to the binding posts on the small terminal board in the lower left of Fig. 2. The voltages generated in these coils were so small that they were amplified by a vacuum-tube amplifier for convenience in reading. Three separate amplifiers were used so that three teeth could be observed simultaneously. The three indicator meters are shown on the box in the center of the picture.

The procedure was as follows: Coils were placed on the pinion of the set of gears under test and the gears placed on the test stand in the usual way. A convenient torque was applied by a weight hung from the pulley on the end of the pinion shaft. The gears were turned by a small motor working through a large reduction on the gear shaft, an arrangement which was available from other work done on the stand. The current through the gears was turned on and the amplifiers connected to the first three teeth by clipping to the appropriate posts on the terminal board. The stand was then turned slowly until the first meter showed a reading indicating that the first tooth was in contact. The stand was then stopped and a reading taken on the protractor mounted on the pinion shaft. Turning was continued until this meter dropped to zero showing that the first tooth had left contact. The first amplifier was then clipped to tooth 4 to be ready for the next engagement. In the meantime the engagement of tooth 2 had been observed on the second amplifier and that of tooth 3 on the third amplifier. In our case no more than three teeth were in contact at once so that the complete picture of the contacts was maintained by clipping the amplifiers to the successive teeth as they approached the contact region. In this way it was possible to determine exactly when each tooth entered and left contact. Measurements could be easily checked to within $\pm$ $^1/_2$ deg on the pinion, (about $^1/_{10}$ deg on the gear) and two or three times this accuracy could be obtained with more care. At first some difficulty was encountered due to currents on the side of the next tooth adjacent to the coil but this was eliminated by checking phase relations.

RESULTS

Space does not permit a discussion of all the results obtained by the use of this new tool for gear study. The purpose of this paper is to outline the method and to indicate some of the kinds of information which can be gained by this method. Doubtless additional points will appear with continued use.

Fig. 3 is a typical series of photographs showing the progression of the instantaneous area of contact on a single tooth during a tooth engagement. These pictures were taken at intervals of 4 deg of rotation on the pinion as indicated by the numbers in the corners of the pictures. The contact is shown by the small dark line on the center tooth in each picture. It enters in the upper left-hand corner on No. 185, gradually moves downward and to the right, being about centered in No. 129, and leaves in the lower right-hand corner in the last pictures. The ordinary "tooth bearing" of this same gear is shown in Fig. 4.

The instantaneous-contact pictures yield a great deal of information not given by ordinary "tooth bearing." The instantaneous contact is essentially a slanting line which moves across the tooth bearing area, and the pictures show clearly the location and the slope of this line. The location of the contact line is important in determining the stresses on the tooth, and the slope is believed to be closely related to the sensitivity to adjustment, and other factors relating to noise. The length of the instantaneous contact area is determined by the position of the line, which is apparent from the photos, and the limits of the tooth bearing area. Several investigators have used a very thin copper plate instead of paint as the marking material for more accurate determination of the limits of the tooth bearing area.

This leaves the width of the contact area as the only factor which is not accurately known, and which is important from the standpoint of lubrication and unit stress on the tooth material. Improved technique always results in finer lines of contact, and some pictures have been obtained which indicate that the width of the contact area is of the order of perhaps ten or fifteen thousandths of an inch. Additional information on this point can be gained by supplementary tests on the given materials with approximately the same curvature, sliding velocity, and load, but with simpler geometry.

Figs. 5 and 6 show typical data obtained on two sets of gears by the electrical method. The angular position of the pinion in degrees is plotted as the abscissa and the voltage generated in the various coils as the ordinate. The meter readings were re-

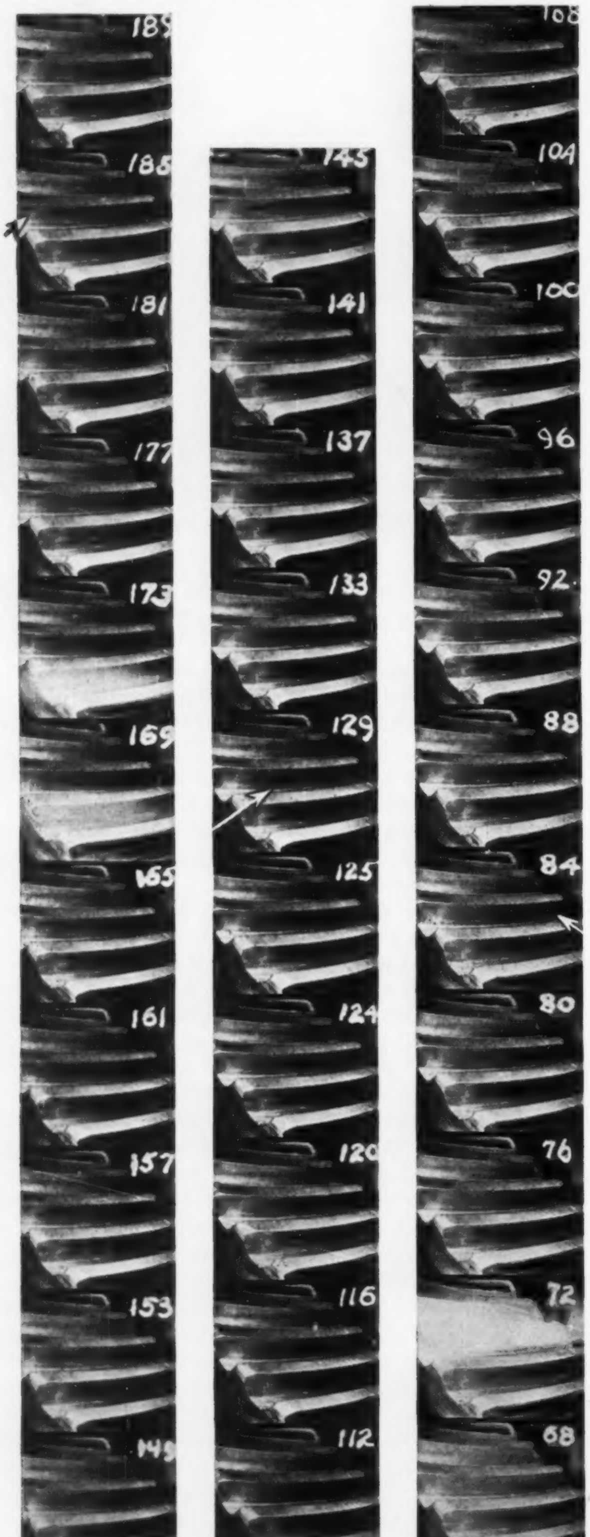


FIG. 3 PROGRESSION OF INSTANTANEOUS CONTACT FOR ONE TOOTH CYCLE

(The arrows point to the contact which appears as a fine dark line on the center tooth in each picture.)

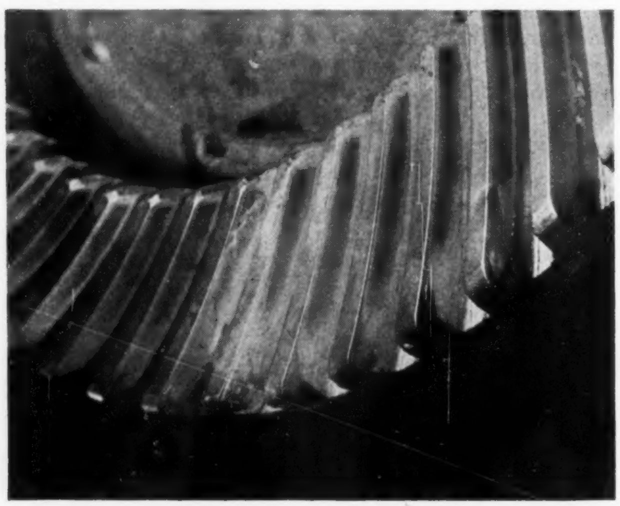
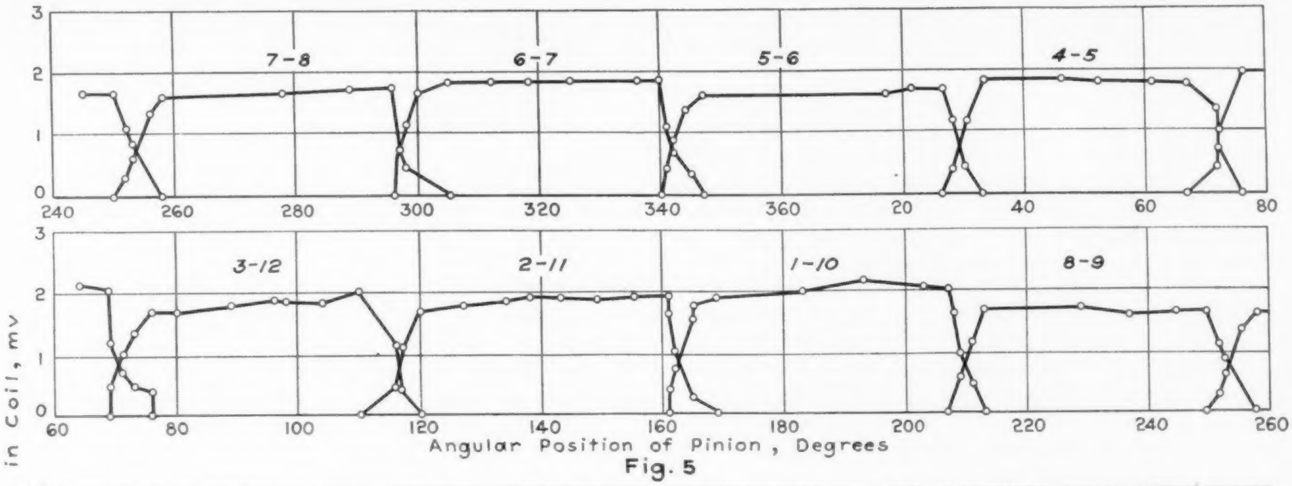


FIG. 4 TOOTH BEARING OF THE GEAR SHOWN IN FIG. 3

(This was obtained by painting the gears with red lead and running them together. The dark area is the wiped area.)



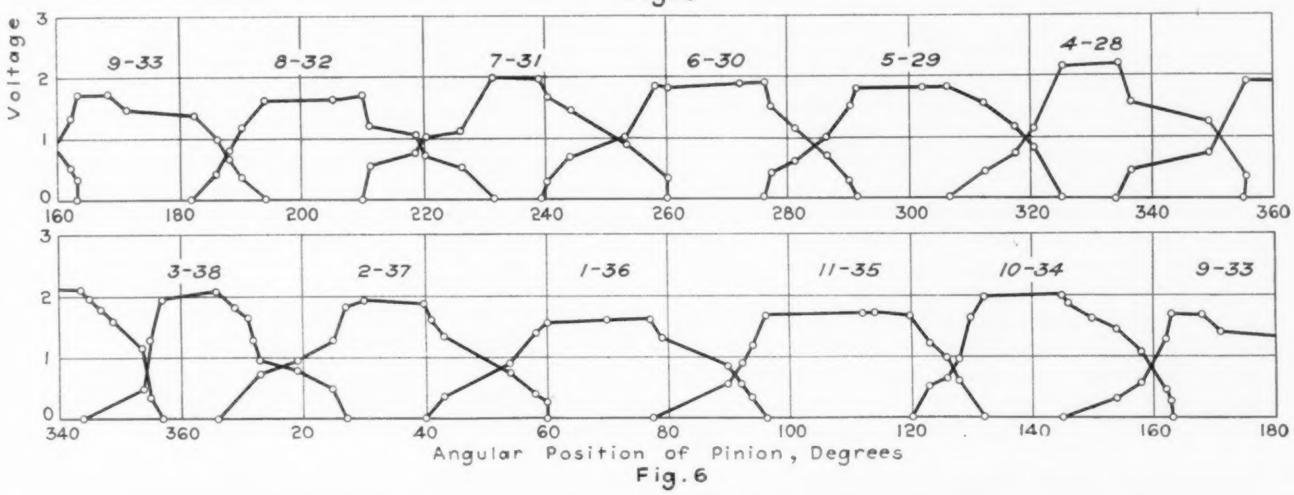


FIG. 5 READINGS OBTAINED ON THE INDIVIDUAL TEETH OF A GEAR SET BY THE ELECTRICAL METHOD

(Gear set A-2; ratio, $5^1/_8$ in.; drive side; zero adjustment; pinion shaft torque, 47 lb-ft.)

FIG. 6 READINGS SIMILAR TO FIG. 5 ON A SET OF GEARS SHOWING MORE OVERLAP

(Gear set D-58; ratio, $5^1/_{11}$ in.; drive side; adjustment, 0.015 in.; pinion shaft torque, 47 lb-ft.)

corded at all points of change and occasionally in between. A curve is drawn for each tooth, the number 3-12, 2-11, etc., representing the numbers of the pinion and gear teeth, respectively. The graphs cover slightly over one revolution of the pinion. In Fig. 5 the overlap was quite small. For example, tooth 2 came into contact when the protractor read 110 deg and gradually picked up the load from tooth 3 until at 120 deg tooth 3 went out of contact. Tooth 2 carried the entire load for 42 deg of rotation when tooth 1 came in at 162 deg and rapidly picked up the load until tooth 2 went out at 168 deg. Fig. 6 shows considerably more overlap and consequently more gradual loading and unloading, but on the average a single tooth carried the load about half the time. It is believed that these data give a fairly good idea of the distribution of the load between the various contacting teeth, and taken together with the photographic data on the location of the contact at the corresponding time would allow tooth stress to be computed with considerable accuracy.

In certain studies it is sufficient to measure only the entry and departure of the contact of each tooth. The angle of rotation of the pinion between these two points is called the "contact angle" for the tooth in question. Figs. 7, 8, and 9 show a group of such graphs taken on a single set of gears. Fig. 7 shows the set as received, Fig. 8 after it had been lapped to a full bearing, and Fig. 9 the same as 8 except that it was tested at a torque of 165 lb-ft instead of 47 lb-ft as were the other two. Additional data on this test are shown in Table 1.

TABLE 1 EFFECT OF LOAD AND LAPPING ON CONTACT ANGLES

	—As received—			— After lapping—		
Load, pinion, lb-ft....	47	103	165	47	103	165
Max. contact angle, deg...............	52	52	53	97	89	68
Min. contact angle, deg...............	48	48	48	89	66	61
Av. contact angle, deg...............	49.6	50.1	50.7	92.8	78.8	63.5
3-tooth contact, per cent...............	...	...	...	6	...	...
2-tooth contact, per cent...............	10	11	13	94	75	41
1-tooth contact, per cent...............	90	89	87	..	25	59

From these data it was apparent that load had a negligible effect on the contact angles with the gears as received, but these had very little overlap. Lapping the gears greatly increased the contact angles, particularly when they were tested at about the same load as that used when lapping, but the improvement

was largely lost when the load was increased. This effect is attributed largely to deflection in the mounting rather than in the gears.

These data also show that the contact angles vary by 10 to 15 per cent among the different teeth on the same gear. In view of the accuracy of these gears this was quite surpri ing. It is believed that such variations might account for large differences of noise from gears which are apparently identical.

In another experiment contacts were measured by the photographic method and the electrical method both before and after lapping. In both cases the photographs showed traces for about 100 deg for each tooth, but the electrical method showed contact for about 75 deg before lapping and about 100 deg after lapping. This indicated that lapping brought surfaces into contact which were close enough to touch the paint before lapping, but which did not actually make metallic contact. Tests showed that the thickness of the paint used on these tests was about 0.0002 in.

CONCLUSION

The results obtained thus far indicate that this is a very simple and powerful method of studying the fundamental action of gear teeth and the comparatively large differences in contact which accompany apparently minor differences in external conditions. Thus far it has been applied only to tests at very slow speeds, but measurements made at this laboratory on the physical errors and sounds produced indicate that the velocities of the secondary motions of good automotive rear-axle gears are so small that inertia effects are believed to be fairly small so that slow-speed tests are quite indicative of running conditions. It is believed that by the use of oscillographic records the electrical measurements could be made on gears under operating conditions at full speed.

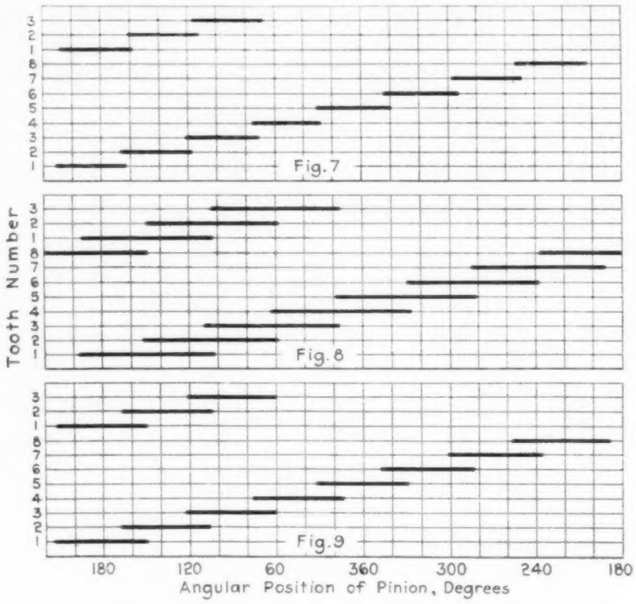


FIG. 7 THE LINES SHOW THE ANGLE OF PINION ROTATION DURING WHICH THE INDIVIDUAL TEETH WERE IN CONTACT

(Gear set A-2; ratio, $5^1/_8$ in.; drive side; zero adjustment; pinion shaft torque, 47 lb-ft; condition, as received.)

FIG. 8 THE CONTACT ANGLES ARE GREATLY INCREASED BY LAPPING THE SET SHOWN IN FIG. 7

FIG. 9 THE SAME SET AS FIG. 8 TESTED AT HEAVIER LOAD (165 LB-FT) SHOWING THE SENSITIVITY OF LAPPED GEARS TO SMALL CHANGES IN ADJUSTMENT, MOSTLY DEFLECTION IN THE MOUNTING

Galloway, N. Y.

ENGINEERS *and the* GOVERNMENT

The Purpose and Program of the American Engineering Council

By FREDERICK M. FEIKER[1]

ALL members of The American Society of Mechanical Engineers have a special interest in the purposes and accomplishments of the American Engineering Council, since, from its beginning as the Federated American Engineering Societies, their representatives have been staunch supporters of the idea behind the Council and many members have served on committees of the Council. Both as the incoming executive secretary of the Council, therefore, and as a member of the A.S.M.E. for many years, I am glad to report to its members.

In a group of meetings beginning with that of the Council itself on January 15, renewed expressions of allegiance to the deeper purposes of the organization have been given both by letters from representative engineers and by resolutions of support from its national and local member bodies. The temper of these comments is contained in the following resolution passed by the Council of the A.S.M.E.:

> Our Society, because of its reduced income, is not able to support the American Engineering Council to the full as it would wish. However, this vote of endorsement may be placed in the record of the American Engineering Council meeting at an appropriate time as evidence that this Society is whole heartedly in sympathy with the purpose of the American Engineering Council and will aid to the fullest extent within its resources.

It is increasingly evident that the founders of this movement for united action by engineers on national problems built soundly. There exists a deep conviction that in these times when our Federal Government is carrying out a program of reconstruction, great in magnitude and expenditure and involving the interests of engineers and engineering, it is especially fortunate that the organized machinery already exists for making the voice of the engineer effective.

AN EMBASSY FOR THE ENGINEERING PROFESSION

While the American Engineering Council and its activities are well known to the men in the profession who have served on its committees and have taken part in its annual deliberations, many members of the constituent organizations are not familiar with its functions and procedures and confuse the Council with other national bodies.

Part of this confusion arises because of the similarity of names we necessarily give to engineering enterprises of community purpose. The American Engineering Council is not a super-engineering society. It is, rather, a cooperative set-up embracing all engineering societies, both national and local, having one definite function—relating engineering-economic opinion and engineering procedures to questions of national policy involving engineers and engineering. Because these national activities head up in one way or another at the Federal capitol, the headquarters of the Council is located in Washington as the engineering embassy of the profession. For thirteen years under the presidencies of leaders in the profession in all branches of engineering, and with the supporting action of several hundreds of individuals who have served on committees, the Council has established in Washington an enviable reputation as a non-partisan headquarters for information and counsel on scores of questions of national policy in all branches of the Federal Government.

THE ENGINEER'S ROLE TODAY MORE THAN A TECHNICAL ONE

Today, more than ever, great policies are in the making in the United States. The Administration under the leadership of President Roosevelt has emphasized the social as well as the economic and technical contributions which engineers have made and will make to our national life. No spokesman for the Administration has put this more succinctly than the Secretary of Agriculture, Henry A. Wallace, when he said before the American Association for the Advancement of Science:[2]

> The men who invented our labor-saving machinery, the scientists who developed improved varieties and cultural methods, would have been bitterly disappointed had they seen how our social order was to make a mockery of their handiwork.
>
> I have no doubt they felt they were directing their talents to free mankind from the fear of scarcity, from the grind of monotonous, all-absorbing toil, and from the terrors of economic insecurity. Things have not worked out that way.
>
> I do not mean to imply that there have been no gains. Of course there have been net gains, even if incommensurate with the hopes and promise of science. Plainly we must hold those gains, and add to them rapidly and extensively; but I think we can do this only if the planning of the engineer and the scientist in their own fields gives rise to comparable planning in our social world.

The American Engineering Council constitutes the mechanism by which, through the cooperation of the leaders in our respective branches of engineering, we may provide a basis for leading men to think more clearly about their relations to these great social and economic questions.

A past-president of the A.S.M.E., Mr. Roy V. Wright, in his notes, "The Engineer's Duty as a Citizen," says that a new definition of engineering is needed. "It was not so many years ago," says Mr. Wright, "that Frederick W. Taylor and his associates had difficulty in convincing the A.S.M.E. that it was concerned with the human element in industry. What a change has taken place! Today and for many years, the management division of The American Society of Mechanical Engineers has been considered one of its most important branches."

[1] Executive Secretary, American Engineering Council, Washington, D. C. Mem. A.S.M.E.

Note: In the February issue of Mechanical Engineering, pp. 96 and 97, there appeared a report of the Annual Meeting of the Assembly of the American Engineering Council, in which Mr. Feiker's appointment as executive secretary of the Council was announced. Comment on the work of the Council appeared in the same issue (p. 99). The present article was prepared by Mr. Feiker in order that engineers might be reliably informed of the present work of the Council and of the views of its executive secretary.—Editor.

[2] The complete address appeared in the March, 1934, issue of Mechanical Engineering.

"This newer conception," I continue to quote Mr. Wright, "of the responsibility of the engineer was clearly reflected in the definition of engineering adopted several years ago by the American Engineering Council: Engineering is the science of controlling the forces and of utilizing the materials of nature for the benefit of man, and the art of organizing the human activities in connection therewith."

The time has now come, as Messrs. Wright, Flanders, Kimball, and scores of other engineers have said, to amend and broaden this definition so that the engineer may understand and meet the responsibilities which are in part the consequences of his contribution to society.

A.E.C. PROVIDES FOR COORDINATED ACTION BY ENGINEERS

We are seeking to find an answer to the capitalistic system in this country in which engineers will accept the social responsibility of controlling unbalanced production and consumption that follow technological advance. To deny further technological advance is to turn our backs on true progress. But we must also not assume that it is some other man's job to evaluate that in terms of economic security for all. We share in that great problem. And for the fulfilment of that great ideal the American Engineering Council provides for all engineers a meeting ground for coordinated action, step-by-step, along logical lines.

The incoming President of Council, John F. Coleman, in his acceptance of that office said:

> The engineer's part in the program of development not only has to do with the technical problems of engineering, but also with the determination of facts which will be of value to the Administration in shaping its policies.
>
> There is ample evidence that opportunity exists for Council to serve both the nation and the profession in ever-increasing degree, and it is earnestly hoped that its officers may be able to fully grasp this opportunity.

A.E.C. ACTIVITIES IN 1934

Since I took over the duties of executive secretary early this year, the Council has been attempting to continue to live up to these high purposes. In a report dated March 9, I outlined the activities of the Council for the month of February. In these few weeks questions of government reorganization affecting engineers and engineering, questions of Federal appropriations for CWA and PWA and their allocation, questions of personnel needs for both present and future governmental activities, questions of renewal of appropriations for certain types of government service which the Council has sponsored in earlier years, questions concerning NRA relations to the capital-goods industries, the relation of engineers in state and Federal organizations to the CWA and PWA—all these have received specific attention from many different angles.

Several conferences and correspondence on the engineer's relation to CWA in cooperation with CWA organizations have included discussions of competition by the Government with private engineering work and the establishment of the principal difference between payment for unemployment relief and the payments of compensation for supervision and counsel.

Informal conferences have been held with construction leaders and engineers regarding ways to stimulate the construction industry, including discussions of further Federal aid, the Securities Act, the Home Loan Bank Act, and Regional Credit, under R.F.C. or the Federal Reserve.

IMMEDIATE POLICY OF A.E.C.

Early in February, President Coleman, acting for the Executive Committee of the Council, reviewed with the staff the general activities and made plans for the coming year. It was agreed that the main objectives of the Council would remain the same. It was further agreed that with our present limited budget and with the demands on our staff, we would try to serve as completely as possible the needs of the members of our organizations in the fulfilment of one function only, mainly, the development of Washington contacts and the relation of those contacts to the specific requests made to us by member organizations. The thought that the American Engineering Council functions as the Washington Embassy for engineers and engineering has had very wide acceptance. Many helpful and constructive comments approving of this phrase and discussing what it means, have been received.

From time to time as President Coleman and I confer with engineers in different localities, we hope to sound out our member organizations and many other organizations, as to the possibility of developing more completely a relationship between the national office and our local member organizations and the local sections of our national organization members. We eventually should represent at Washington a well-knit organization in which we have at the principal industrial and engineering centers contacts on national affairs, which will both act as a sounding board for the Council on national affairs and initiate ideas with regard to them. This is not a program of duplicating other organizations but, on the contrary, the finding of ways of relating the Council and its definite functions to all organizations which possibly would be interested in the development of such a relationship. Arrangements have been made for monthly meetings of the executive secretary with the secretaries of the Founder Societies and with the administrative officers of other member bodies. At the February meeting the secretaries expressed themselves as hoping to aid in every way to further wider knowledge of what the Council was doing.

THE MEN BACK OF THE A.E.C.

These few evidences of what the American Engineering Council is and what it is doing today show why the leaders of the engineering profession have always been represented in its activities. The late W. S. Lee, retiring president for the year 1933, gave a graphic picture of the relation of engineers to the Council in his presidential address. He said in part:

> Two hundred and forty-two individuals have been members of the Assembly since the organization of Council. Among these have been the following: 45 presidents of Founder Societies, 25 presidents of other national societies, and 69 presidents of state and local societies. In other words, 139 presidencies of the national, state, and local engineering societies have been held by members of the Assembly.

Mr. Lee pointed out that these engineers who had constituted the Council were those who had risen to leadership in the fields of industry, education, and public service, being presidents and vice-presidents of manufacturing and utility companies, presidents and deans of engineering colleges, and consultants and holders of high public office.

THE WORK AHEAD FOR THE A.E.C.

Of the problems of reconstruction just ahead Mr. Lee stated:

> Soundness of planning, thoroughness of construction, use and need of the project to be constructed, efficiency in the use of labor and of the nation's resources of power and materials will be important factors and occupy prominent places. This must continue to be, if the greatest service to the public and the engineering fraternity is to be rendered, and the impress of engineering on public affairs fulfils its greatest use.
>
> We have been endeavoring for years to promote the public good and the engineering fraternity's good. This work has been done to a large extent through the American Engineering Council.

WATER TREATMENT *for* BOILER FEED

By S. B. APPLEBAUM[1]

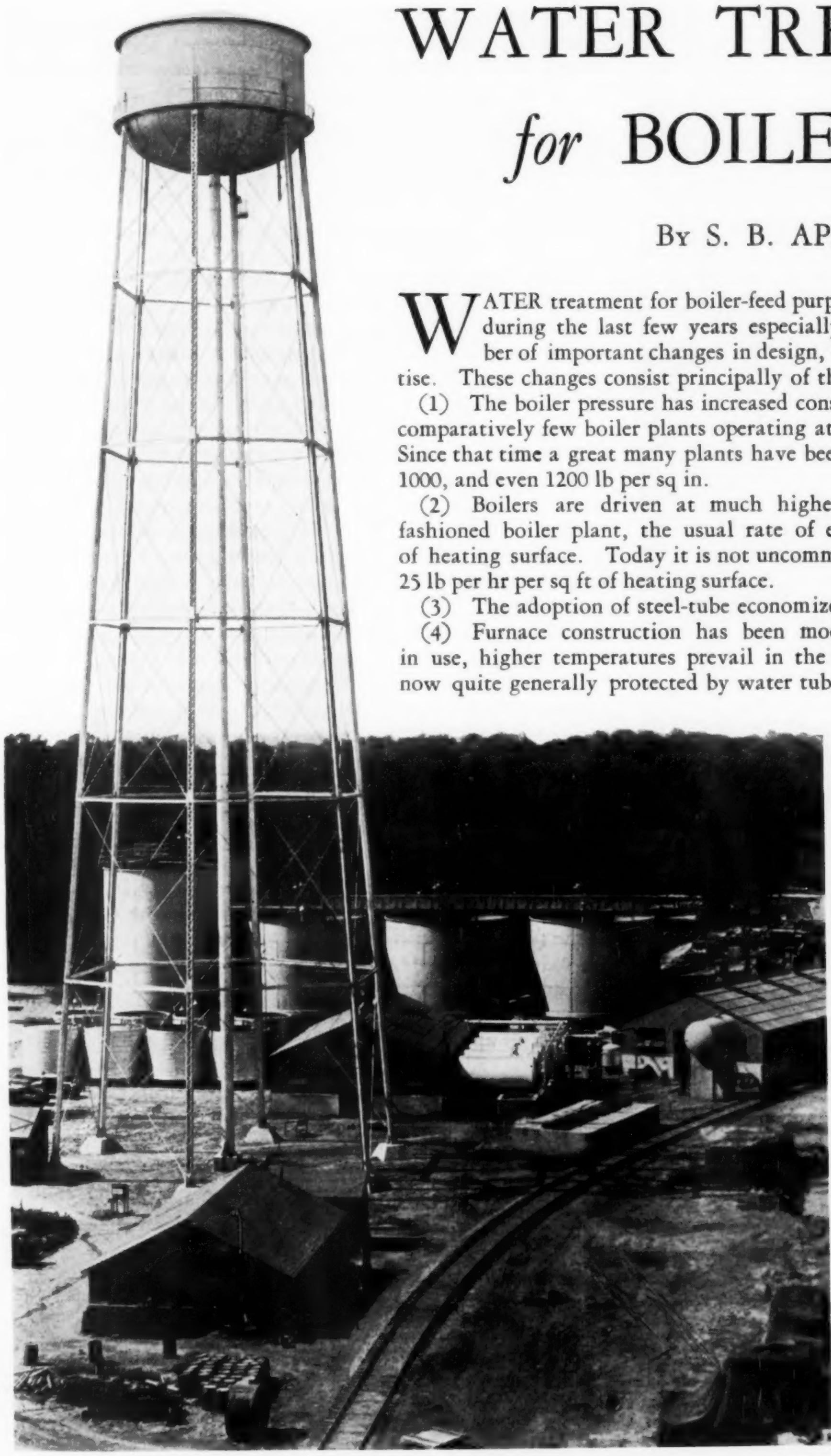


FIG. 1 COMBINATION LIME AND ACID AND ZEOLITE PLANT REMOVING THE MUD AND SCALE-FORMING MATERIAL FROM MISSISSIPPI RIVER WATER

(Installed in a Louisiana steam plant consisting of three 1400-hp boilers operating at 600 lb pressure and 800 per cent rating, evaporating in excess of 1,000,000 lb of water per hr. The make-up is 80 per cent of the evaporation. See Fig. 4 for flow diagram.)

WATER treatment for boiler-feed purposes is a subject of timely interest because, during the last few years especially, steam boilers have undergone a number of important changes in design, which have modified water-treatment practise. These changes consist principally of the following:

(1) The boiler pressure has increased considerably. About ten years ago there were comparatively few boiler plants operating at a pressure in excess of 400 lb per sq in. Since that time a great many plants have been installed with pressures of 400, 600, 800, 1000, and even 1200 lb per sq in.

(2) Boilers are driven at much higher ratings than previously. In the old-fashioned boiler plant, the usual rate of evaporation was 3 to 6 lb per hr per sq ft of heating surface. Today it is not uncommon to hear of rates of evaporation of 10 to 25 lb per hr per sq ft of heating surface.

(3) The adoption of steel-tube economizers has become more common.

(4) Furnace construction has been modified. A greater variety of fuels is now in use, higher temperatures prevail in the boiler furnaces, and the furnace walls are now quite generally protected by water tubes or water screens.

The effect of these changes in the design and operation of boilers in the modern power plant has been to call for greater thoroughness in the water treatment. In the older types of boilers, thin scale deposits were not always such a serious matter. It was merely accepted as the ordinary method of operation to expect turbinings of the boiler tubes at regular intervals. But with conditions of higher rates of heat transfer, higher boiler pressures, and higher temperatures, it is obvious that even paper-thin scales or deposits on the heating surfaces of boilers can no longer be tolerated. In passing a certain number of heat units through clean boiler metal at a given rate, a certain differential in temperature between the water and gas sides of the metal is required, but in order to pass the same quantity of heat units through scaled boiler metal at the same rate, a much higher differential in temperature is necessary. Scale thus elevates the temperature in the metal of the boiler tubes. A temperature of 900 F is usually considered dangerously high; and it has been calculated that scales as thin as 0.03 in. may cause a temperature in excess of 900 F to exist in the boiler tubes. This serious overheating of boiler metal results in bulging, bagging, and burning of boiler tubes.

The more common use of steel-tube

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From a paper presented at a meeting, Boston, Mass., October 19, 1933, of the Boston Section of The American Society of Mechanical Engineers. The present paper is only a part of the original. The portion of the paper dealing with recent mechanical improvements in the treatment of boiler feedwater will be published in a later issue.

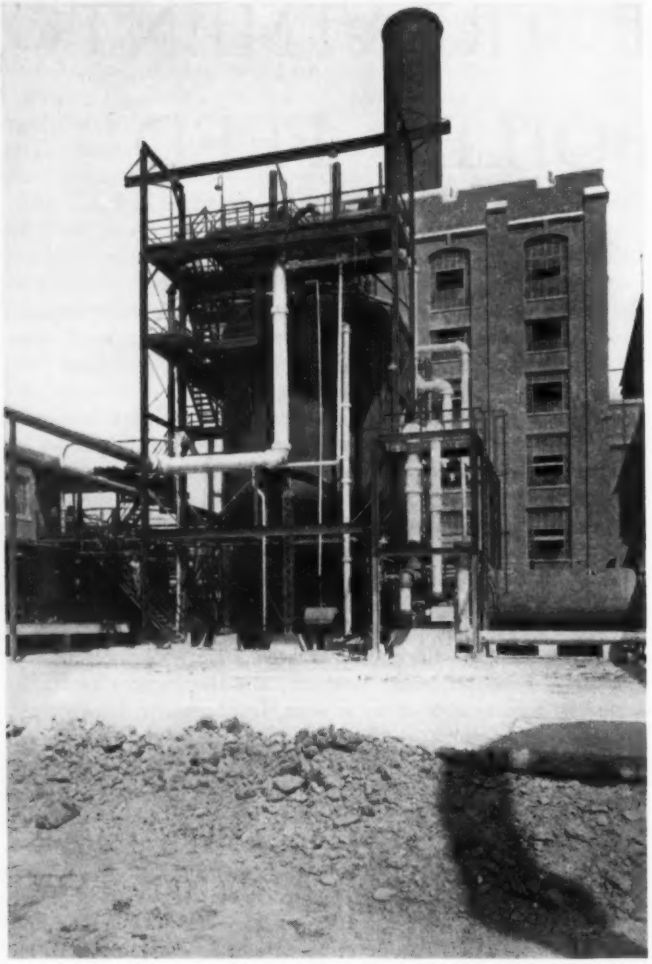


FIG. 2 HOT-LIME SOFTENER FOR BOILER FEED IN AN OIL REFINERY
(Acid treatment precedes the lime treatment to neutralize sodium bicarbonate. Ferrous sulphate is added for complete oxygen removal. Capacity, 2,500,000 gpd.)

economizers and the greater investment in high-pressure boilers in general have also called for greater care in the deaeration of water to prevent corrosion.

Furthermore, the operation of boilers at higher ratings with the smaller water volumes available in the boiler drums has caused higher concentrations of solids to develop in the water inside the boiler in a given period of time. Therefore, more frequent boiler blow-off was required to remove concentrated liquid from the boiler and replace it by fresh feedwater in order to prevent the carry-over of liquid from the boiler into the steam lines, caused by too high a concentration. This has logically resulted in the development of continuous boiler blow-off equipment, which maintains a fairly constant concentration in the boiler and at the same time permits absorption of heat from the blow-off stream.

SPECIFICATIONS OF IDEAL FEEDWATER

These changes in boiler design have therefore made it necessary to raise the standards of boiler feedwater treatment and today an ideal feedwater must fulfil the following specifications:

(1) No scale, no sludge, and no mud must be deposited on the boiler heating surfaces.

(2) The water must be as free from oxygen as possible to prevent corrosion in the feedwater system and the boilers.

(3) As an added precaution, in case some oxygen might slip through at times, it is desirable to require a pH value greater than 8.0 in the feedwater to protect the feedwater system and especially the steel-tube economizers.

(4) To prevent carry-over, the feedwater treatment plant must include means to insure continuously low concentrations, the maximum limit of which will depend upon the type of boiler and ratings at which the boiler is operated.

INHIBITION OF "EMBRITTLEMENT"

It has been known for many years that serious cracking occasionally occurs in riveted boiler drums. Two theories to account for this have been advanced by opposed schools of thought. One group of investigators attributes this cracking to faulty workmanship, excessive cold working of the metal, improper drawing-up and fitting of the boiler plates in seams, too free a use of the drift pin, and excessive pressures in riveting, all of which result in setting up undue internal stresses in the metal during manufacture, so that when subjected to the additional stresses encountered in use, cracking finally occurs. In support of this view, cases have been cited where cracking in one or two boilers of a series, operating on the same water, occurred, while the other boilers have shown no cracking even after much longer use. Also, boiler drums have been known to crack during shipment before ever being put in use.

The other group of investigators attribute this cracking to high concentrations of caustic soda in the presence of relatively low concentrations of sodium sulphate, combined with stresses in the metal beyond the yield point. The concentration which is claimed to have this accelerating effect is about 100,000 parts per million. Obviously, such concentrations do not exist in the contents of a boiler, but it is claimed that these concentrations develop in seams and around rivet holes when the boilers are calked on the outside. It has also been suggested that the accelerating effect of caustic soda may be prevented by maintaining the presence of certain inhibiting constituents in the feedwater, such as sodium sulphate, sodium carbonate, and sodium phosphate. These salts are less soluble than caustic soda and when the concentrations claimed to take place within the seam spaces occur, these less soluble salts crystallize out first and fill up the space, preventing contact between the metal and caustic soda.

As a result of the latter theory, the Appendix of the A.S.M.E. Rules for the Care of Power Boilers suggests tentatively that the following ratios of sodium sulphate to total alkalinity expressed as sodium carbonate be maintained: For boiler working pressures up to 150 lb per sq in., the ratio is 1; for pressures from 150 to 250 lb it is 2, and for pressures above 250 lb it is 3.

In attempting to explain why many boilers have operated over long periods of time apparently without complying with these ratios and with no signs of cracking, some have advanced the theory that sodium carbonate, as well as sodium sulphate, is an inhibitor and that cracking will be inhibited if the following ratio is maintained:

$$\frac{Na_2SO_4 + Na_2CO_3}{NaOH} = 2$$

As to feeding phosphates for the inhibition of cracking, the following rule has been set up by the proponents of the phosphate inhibition theory.

For boilers operating at pressures below 250 lb per sq in., 40 ppm of soluble PO_4 should be maintained in the boiler salines. In boilers operating at pressures greater than 250 lb where the alkalinity in the boiler salines is less than 1300 ppm, this same concentration should be

maintained, but if the alkalinity in the boiler salines is greater than 1300 ppm, 20 ppm of PO_4 for every 400 ppm of additional alkalinity should be added in addition to the minimum 40 ppm.

FORMS OF WATER TREATMENT AVAILABLE

In the *distillation* process, the make-up water is vaporized in an evaporator. The condensed vapor becomes the make-up feedwater. An evaporator installation merely transfers the problem of scale deposits from the boilers to the evaporators.

In the *cold-lime-soda* process lime and soda ash are added to the water at normal temperatures.

Hot Lime Soda. For boiler feed use the hot-lime-soda process has practically displaced the cold treatment in a great majority of cases. The chemical reactions are the same but the water is first preheated to the boiling point. Higher temperatures result in greater speed of chemical reaction; therefore, the settling tank is usually reduced to one-hour detention period instead of the four hours used in the cold. Settling takes place more readily because the precipitates are formed more thoroughly and the precipitates settle better in hotter and therefore lighter water. See Fig. 2.

Zeolite. In the zeolite process the water is softened by passing it through a bed of granular zeolite, softening being effected by the base exchange properties of the zeolite. During the softening run the calcium and magnesium salts, which constitute the hardness of the water, are converted by this base exchange into the corresponding sodium salts which, of course, are extremely soluble and non-scale forming.

These base exchange reactions are reversible. Therefore, the zeolite can be regenerated to its original condition by treating it with a solution of common salt. This is termed regeneration. During regeneration the sodium in the salt solution goes into the structure of the zeolite and the calcium and magnesium go into solution and form calcium and magnesium chlorides. These, with the excess of salt, all in solution, are washed to waste, leaving the zeolite in its original active sodium state. These alternate softening runs and regenerations may be repeated an indefinite number of times. Fig. 3 shows a large zeolite plant.

Lime-Zeolite. The combination of cold-lime treatment followed by zeolite has been used with success. The lime pretreatment reduces the temporary or bicarbonate hardness of the water and the zeolite completes the removal of this temporary hardness, as well as the removal of the permanent or non-carbonate hardness. As a precaution some acid, acid salt, or CO_2 from flue gas should be added to the lime-pretreated water to neutralize the excess of reagent and prevent after-precipitates of calcium carbonate on the zeolite grains.

Internal Treatment. In internal treatment the softening reagents are added to the water inside the boiler and the precipitates formed are removed through the blow-off valve. The principal reagent used is soda ash, although recently phosphate has gained some popularity.

FIELDS OF APPLICATION OF THE VARIOUS FORMS OF TREATMENT

The distillation process is principally used in central power plants where the percentage of make-up is very low. Internal treatment is used where the amount of hardness to be removed is very small, so that the precipitates formed inside the boiler do not constitute an excessive burden of suspended matter. The cold-lime-soda process is used in railroad and other plants where it is impracticable to preheat the water first.

The two methods of water treatment most generally employed for boiler-feed purposes are hot lime soda and zeolite. The decision as to which of these two methods to employ requires a careful study of a number of the following factors:

(*a*) The composition of the water
(*b*) The constancy of composition of the water
(*c*) The space available
(*d*) The type of boiler, and the pressure and rating at which the boilers will be operated
(*e*) The type of labor available to operate the plant
(*f*) The cost of operation and the fixed charges.

Composition of Water. Lime in the hot-lime process reacts with the bicarbonate hardness to form calcium carbonate and magnesium hydrate, which are removed by precipitation, settling, and filtration. Therefore, if there is an appreciable bicarbonate hardness present in the raw water, the total quantity of dissolved solids is actually reduced in amount by the lime treatment. The zeolite process, on the other hand, does not reduce the total quantity of solids, but merely converts the calcium and magnesium bicarbonates to sodium bicarbonate.

Because of this difference in the two processes, it is important to know the amount of bicarbonate hardness in the raw water before making a choice between them. In general, when the bicarbonate hardness of the raw water is high, the hot-lime-soda process is favored, although it is difficult to fix any exact limit of bicarbonate hardness above which one method of treatment is to be preferred to the other, and the almost universally adopted practise of employing continuous boiler blow-off has, in great part, overcome the advantage which hot lime soda possesses of reducing the amount of total solids.

The effect of a smaller quantity of total dissolved solids in the feedwater is to reduce the amount of blow-off necessary to maintain a given concentration in the boiler salines. If,

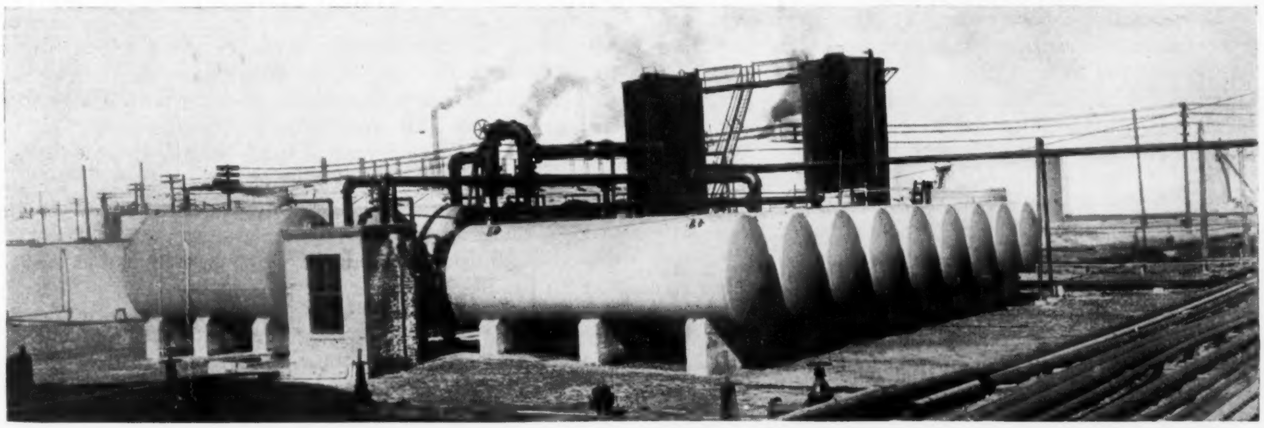


FIG. 3 FILTRATION PLANT FOLLOWED BY ZEOLITE SOFTENERS FOR BOILER-FEED PURPOSES, CAPACITY 6,000,000 GPD

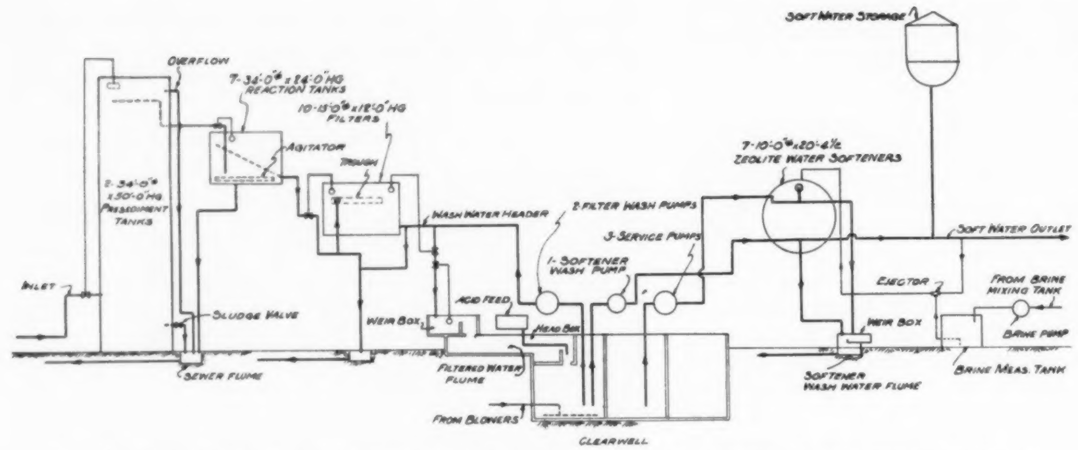


FIG. 4 FLOW DIAGRAM OF COMBINATION LIME AND ACID AND ZEOLITE PLANT SHOWN IN FIG. 1

for example, a boiler should operate with a concentration of less than 300 grains per gallon of total dissolved solids in the salines in order to prevent wet steam, and the feedwater contains total dissolved solids to the extent of 15 grains per gallon, the amount of blow-off required is about 5 per cent of the total evaporation. If, on the other hand, the total quantity of dissolved solids in the feedwater is $7^1/_2$ grains per gallon, a blow-off of only $2^1/_2$ per cent is sufficient to maintain the same limit of concentration in the boiler. When boilers were blown off intermittently, the saving of half the blow-off water represented a considerable saving in the heat. For that reason, lime treatment for reduction of bicarbonate hardness and consequent reduction in the quantity of total solids was of greater importance. Today, when boilers are blown off continuously and the heat in the blow-off water is extracted and conserved, the difference between 5 and $2^1/_2$ per cent of the evaporation is not so important as long as the heat is conserved by proper heat exchangers. Thus the continuous boiler blow-off has taken the place of the reduction in total solids by lime treatment.

Constancy of Composition. The amounts of lime and soda ash required in the lime-soda process depend upon the amounts of the various types of hardness present in the raw water. If the supply is well water of fairly constant composition, the amounts of lime and soda ash required for the best treatment are determined by calculation and field adjustment at the time the plant is started, and a relatively unskilled operator can continue to administer this constant dosage from that time on. The feeding devices then merely have the function of proportioning the correct amount of chemicals to the flow of water.

However, if the water comes from a surface supply, such as a river, the rainfall at different seasons of the year has a marked influence on the composition, so that the amounts of the various forms of hardness present vary widely. Variations of 100 per cent in one month have been observed on one river. A hot-lime-soda plant handling such a water must not only be accurate in proportioning the amount of chemical to the varying flow of water, but must also change the dosage. This is not accomplished automatically by any feeding device and is therefore the function of the operator. He must make daily analyses of the raw water and change the dosage accordingly. If the hardness rises and the dosage is not increased, the water is undertreated. If the hardness of the raw water decreases and the treatment is not changed, the water is overtreated, resulting in the presence of lime which in itself, of course, causes hardness.

In the case of zeolite treatment, there is no dosage of chemicals. The effect of changes in the composition of the water is merely to increase or decrease the length of the run between successive regenerations of the zeolite. The quality of the effluent is not affected. The zeolite removes the hardness completely, whether the water contains 10 or 5 grains per gallon. The speed of softening is very great, the reaction taking place almost instantaneously.

Therefore, it may be stated that hot lime soda is better suited to treat waters of constant composition, whereas zeolite can handle either a constant composition or a variable composition.

Space Available. Hot-lime-soda plants require a settling tank of sufficient size to provide for a one-hour detention period, and also filters and chemical feeds. Space must be available, therefore, both in floor plan and elevation, to accommodate this equipment. Zeolite softeners usually take up no more space than the filters of a hot-lime-soda plant.

Where the raw water is clear and does not require prefiltration ahead of the zeolite, the zeolite plant is more compact. This is an important consideration in some cases, because, if the hot-lime-soda plant requires new buildings, their cost may be as much as that of the equipment itself, while it may be possible to find room for zeolite softeners in an existing building.

Type of Boiler, Boiler Pressure, and Rating. The hardness of the effluent of a hot-lime-soda plant depends upon the excess of soda ash employed. As this excess is increased, the hardness decreases. In general, it is customary to operate a hot-lime-soda plant so that the hardness of the effluent is about $1^1/_2$ to 2 grains per gallon with an excess of soda ash of $1^1/_2$ to 2 grains per gallon. If a greater excess of soda ash is employed, not only is the operating cost greater but the amount of soda ash in the effluent will, in most cases, exceed the amount of sodium sulphate present and make it difficult to maintain the suggested sulphate-carbonate ratio to inhibit embrittlement. To offset the excess of soda ash, it would be necessary to add sodium sulphate, which would further increase the cost of treatment and at the same time increase the total amount of dissolved solids.

This residual hardness of $1^1/_2$ to 2 grains per gallon does precipitate in the boiler and the character of the deposit formed by this precipitate depends, to some extent, on the sulphate-carbonate ratio. If the sulphate-carbonate ratio is kept high, to satisfy those who recommend high ratios to inhibit embrittlement, then the deposit is hard, because sulphate scale is harder than carbonate scale.

Where boilers are operated at high pressures and at high ratings, the presence of even slight amounts of hard scale is dangerous, because of the tendency to burn the tubes. Therefore, in hot-lime-soda plants for boilers operating at pressures in excess of 200 lb a secondary internal treatment is adopted. Sodium aluminate or phosphate or some other reagent is added in the boiler to prevent trouble from the formation of hard scale from the precipitation of the residual hardness in the lime-soda effluent. The use of these reagents inside the boiler involves extra operating expense. In many cases, the cost of the internal

treatment with phosphate exceeds the cost for the lime and soda ash. Furthermore, the use of internal treatment following hot lime soda has the disadvantages, already mentioned, of internal treatment in general.

For high boiler pressures and high ratings, the zeolite process is preferred because no internal treatment is necessary as a secondary step, provided the condensate returns are not contaminated by hard water. The hardness of zeolite-treated water is practically zero. Therefore, there is no residual hardness to be precipitated in the boiler and no scale, sludge, or mud forms in the boiler. The appearance of the boiler salines drawn from boilers fed with zeolite-treated water testifies to the absence of hardness in the feedwater, because the saline is a practically clear water. The clarity of this boiler saline is advantageous in inhibiting the tendency for carry-over and wet steam.

Labor to Operate Plant. The larger the installation and the better the type of supervision, the more favorable it is to operate a hot-lime-soda plant. A certain amount of chemical supervision is required to insure the best treatment.

In the case of zeolite, regeneration of the softener with brine is purely mechanical in nature, requiring no skilled labor. Furthermore, the introduction of the automatic zeolite softener has still further simplified the handling of zeolite softeners.

Cost of Operation and Fixed Charges. In every case, the cost of operation and fixed charges should be carefully analyzed, allowing for all the reagents that are required for softening, secondary internal treatment, and inhibitants against so-called embrittlement. In general, it may be stated that a hot-lime-soda plant is more economical on waters high in bicarbonate hardness, because lime is usually half as costly as salt for removal of bicarbonate hardness, whereas soda ash is generally twice as expensive as salt for removal of non-carbonate hardness.

As far as fixed charges are concerned, the cost of hot-lime-soda plants in general does not vary appreciably with the composition of the water. The only factor which influences this cost is the amount of water to be treated. In the case of zeolite, however, both the amount of water and the composition of the water affect the investment. The volume of zeolite and the size of the container for the zeolite decrease if the hardness decreases. In general, therefore, the fixed charges will be lower for hot lime soda than for zeolite with high hardness of the raw water. But for waters having hardness under about 15 grains per gallon, zeolite is less expensive.

Combination Lime-Zeolite Plants. A combination lime and zeolite treatment finds application for waters of high bicarbonate hardness, using the lime which is the cheapest reagent for the removal of the bicarbonate hardness and using the zeolite for removal of the residual bicarbonate, as well as the non-carbonate hardness. In this way, the lowest cost of operation is obtained.

Frequently, the source of raw water is from a surface supply that requires clarification ahead of the zeolite and by using a little larger settling tank and using lime, lime presoftening is accomplished together with the clarification. Sulphuric acid is added after the filters, but before the zeolite, so as to neutralize the phenolphthalein alkalinity to zero and decrease the pH to 7 to 7.5 and thereby prevent the coating of the zeolite grains by after-reactions. Fig. 4 is a flow diagram of such a plant. Another field of application for the combination treatment is for plants that require treatment of condenser cooling water as well as boiler feedwater. The lime pretreatment is used for the condenser cooling water alone and the zeolite is added to finish off the treatment for the boiler feed.

The Importance of the PRODUCT *in the* RECOVERY PERIOD

BY W. E. FREELAND[1]

THERE is nothing in the plans for promoting the recovery of American industry to indicate that competition will be less intensive, even though our new codes of fair practise aim to place competition on a higher plan of ethics and morals. There is no indication that the competition between industries for the same consumer dollar will be lessened. There is no indication that strategy relative to products and product design will be replaced by the activities of any other part of the organization of industrial enterprises.

Competition to maintain a place in the sun of public favor is virtually certain to be more intensive in the recovery period than in normal times. Once our manufacturers gain some assurance that a return to normal business has actually begun, there will be such an outburst of energy in marketing as to produce new problems for all industry. It can be predicted that products will have a place in the forefront of management's problems as industrial competition moves out of the area of price competition which has characterized the depression period.

Product thinking in periods of intensive price competition naturally centers around costs. Savings in materials and operations are of paramount importance. Insidiously the thought that consumers are interested only in price creeps into management thinking and other consumer reactions to product are neglected or ignored. Every recovery period has been marked by the rapid rise of those industrial enterprises which have utilized the period of low volume to get their products redesigned, or new products designed, ready for the period when consumer budgets permit the resumption of normal buying.

Price will always be the most important single factor affecting product design and remains the dominant factor in goods made for mass distribution. Consumer reaction to products, however, goes beyond price into consideration of quality, service, durability, utility, convenience, appearance, refinement, and various intangible values affecting consumer desire and decision.

Great markets await those who can add these other values while so designing their products as to break measurably through the bottom of former price levels. No better example

[1] Boston, Mass. Assoc. A.S.M.E.

Contributed by the Management Division and presented at the Annual Meeting, New York, N. Y., December 4 to 8, 1933, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

could be found than the expansion of the market for midget radio sets in the period between 1930 and 1933. A recent survey shows that, in homes with incomes over $10,000, the increase in number of homes with radio sets has been but 12.5 per cent, but the increase in homes of the $1000 to $2000 class has been 67.1 per cent, and in homes with incomes under $1000 has been 164.7 per cent.

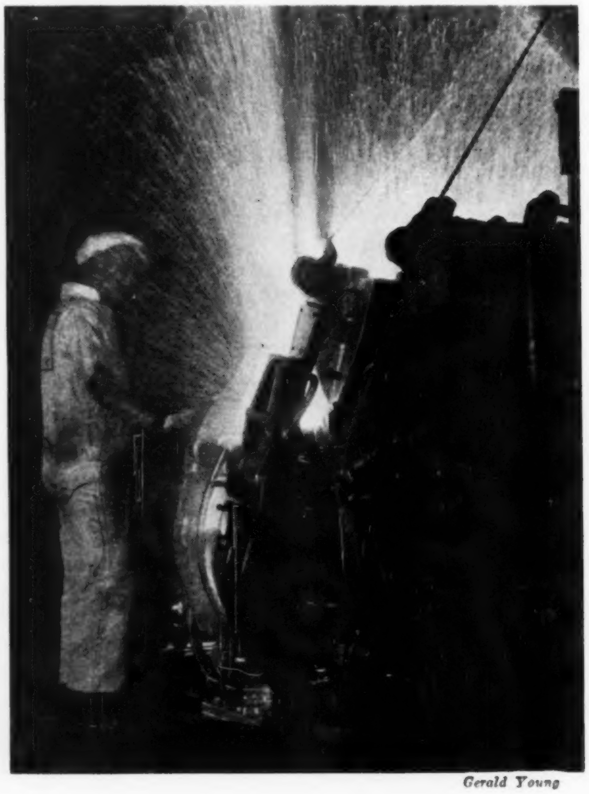
Products that gain prompt and favorable trade and consumer reactions will almost invariably be found to be those to which design, engineering, and merchandising have jointly made their proper contributions. Design ignoring the engineer is usually productive of higher factory costs; design ignoring merchandising is usually productive of high consumer resistance.

It can be safely said that many a good sales organization is working hard to maintain sales of products tolerated by the public because of their utility but not so designed as to compete for the consumer dollar against products offering other values obvious to the public. Too many products are designed to meet competition within their own industry, ignoring to a large extent the fact that the consumer has freedom of choice as to what product he will purchase with his free surplus beyond the necessities of life.

Coal, gas, and electricity compete for the decision of the housewife in the choice of a range for her kitchen. Piano, radio set, and phonograph compete for the dollars the household can spare for entertainment. Television is just coming over the horizon to compete with these with its tremendous appeal of novelty. The automobile successfully competes for the first free dollars of the consumer's increasing income. Competition is definitely intra-industry, not inter-industry.

So product design must not take into account utility, service, and price appeal only. Too much of the consumer's decision rests upon the emotions rather than logic or reasoning to allow product design to rest upon the simple and obvious objectives of utility, service, and price. There is a large cash value in external appearance. The new and distinctive product appeals to our American public in ways which are promptly reflected in increased sales. This is particularly true in products which are sold through retail stores, because the new products enlist the interest of the retail clerk, wearied by endless repetitive presentation of the sales points of old and familiar products. The retail clerk is the real salesman of retail products and his interest is one of the most influential factors in the success of the manufacturer's sales program.

New products should be designed to a specific price level, but not necessarily to the low price level. Some of the greatest opportunities lie in the fact that a great gap may exist in the price levels at which competitive products seek a market. The manufacturer who first designs a product to fill such a price gap may have an almost exclusive market until competition wakes up and overtakes him, and even then his priority may have helped him to dominate the market at that price level for some time.


Gerald Young

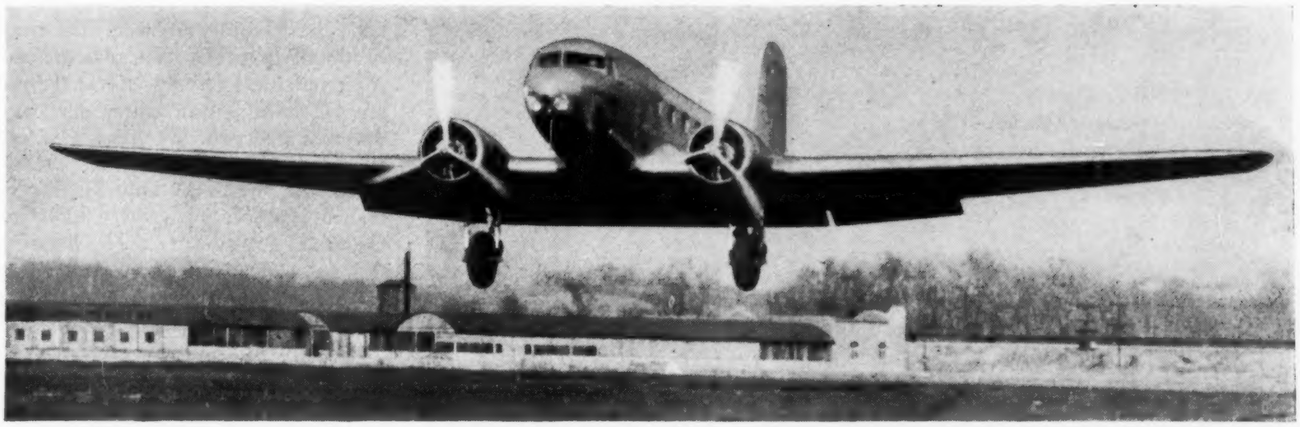
Manufacturers who make machinery or equipment for offices or households must take into consideration more factors than have been outlined. They must take into account ease and continuity of operation, ease of repair, and standardization of apparatus and parts. Yet they cannot neglect the factors of multiple utility, appearance, and finish and color. Products of this class are particularly those in which adequate market tests, as well as laboratory tests, should precede public presentation. The user will often find "bugs" which no laboratory test has disclosed.

We have been hearing much in the last few years about obsolescence as a great factor in increasing sales. It is a moot question as to whether creating a market by new product design which makes existing products obsolete is economically, perhaps socially, sound. The evidence is clearly presented, however, that the public responds to products which do produce obsolescence of prior products. It is part of our American nature to crave those things which enable us to take credit for being "up-to-date" and possession of which is presumably taken by others as evidence of our financial and social standing. It is a normal part of our national enterprise to raise our standards of living. The manufacturer who can make his own and competitive products obsolete by new product design has a live and large market awaiting him, particularly in a recovery period.

Other problems come up in relation to the development of new products. These problems usually require more research than is given to them, particularly as to their effect upon production and marketing organizations and programs and, therefore, upon the decision to adopt these new products to add to growth and profits. Sometimes there is a great temptation to undertake the production of new goods not allied to present products and therefore calling for new equipment or a new sales organization, either of which steps may ultimately prove to more than absorb the prospective profits.

More often than not, the fact that a second sales organization will be necessary is not analyzed or interpreted into figures to disclose the additional capital investment which will be necessary to reach the objective. Upon this rock many a business has foundered.

If a product is new, distinctive, and exclusive, ways can usually be found to organize and finance to reach the objective. If the new product is just another product in a crowded field, it is essential that adequate financial and market research be conducted and such research be recognized as part of the financing of new product development. Such studies disclose the real opportunity, measure the probable gain to the business as a whole, and are a distinguishing mark of capable industrial administration.



TWA AIRLINER LANDING AT KANSAS CITY AIRPORT AFTER A FLIGHT FROM LOS ANGELES AT A RATE OF 200 MILES PER HOUR

Developments in AIR TRANSPORTATION

By RICHARD W. ROBBINS[1]

THE year 1933 marks a turning point in the affairs of air transportation.

From the beginning of scheduled air transportation in the United States in 1928, the operators have been faced with the necessity of convincing the public that they should travel in airplanes which, as compared to present-day equipment, were both slow and uncomfortable. These airplanes were the result of the adaptation of basic military designs to commercial usage. Neither the aircraft manufacturers nor the operators were then able, because of lack of experience, to formulate specifications for the ideal transport airplane.

During the last two years the operators and the aircraft manufacturers have been busily engaged in the development and production of transports which would meet the demands of a discriminating public. This year has seen the results of these labors take to the air with far-reaching effect upon air-passenger transportation.

Speed has been the airplane's greatest asset. Yet the speed of transport airplanes had not kept pace with the advance in the science of aerodynamics and aircraft construction for several years. This was true because the transports which had been the mainstay of air-passenger transportation had proved themselves practically indestructible through normal operation—and, further, the financial condition of the air lines has required conservation of all equipment which might safely be operated. The fact that practically all equipment in use during the year 1931 was obsolescent was recognized by the airplane operators.

The tri-motored Ford airplane has been the most prominent passenger transport in this country since 1928. It was the first type of large airplane, built of all-metal construction, to achieve universal success. Until this year its performance, dependability, and economy of operation had led the field of transport airplanes. However, these tri-motors, cruising at 125 mph or less, and with a passenger cabin cramped for space and noisy, have in reality been obsolescent for several years.

Although Lockheed single-engine airplanes pioneered the way among fast commercial aircraft, they were not used by the major airline operators until 1933. The Lockheed "Orion" type, which was also the first fast commercial type to have a retractable landing gear, is now in use by one major airline exclusively on mail schedules. Another major operator used them to carry mail and passengers. These "Orions," equipped with Pratt & Whitney S1D1 Wasp engine and a controllable-pitch propeller, have shown a cruising speed at altitude of about 200 mph.

This year has seen the arrival of the ten-passenger Boeing 247, a new departure in transport aircraft. It led the way in the change from the all-metal cantilever high-wing monoplane type of design (Ford, as example) to the low-wing type. It also embodies a new type of metal construction in that the skin of the fuselage and wing is smooth and carries a share of the structural stress. The low-wing feature is essential to efficient employment of a retractable landing gear in the monoplane type. This plane has a cruising speed of approximately 170 mph, and in scheduled operation has maintained a station-to-station speed of 155 mph. Improved chairs, wider aisle, and considerably lower noise level than in the Ford have all combined to make this airplane popular with air travelers.

Another new transport to be welcomed by the public this year has been the new Curtiss-Wright "Condor." This 15-passenger airplane is a biplane, of metal construction and fabric covered, with retractable landing gear. It has a cruising speed of 140 mph. It is the first airplane to be scientifically soundproofed, with the result that the noise level in the passenger cabin is lower than in any other passenger transport previously operated.

[1] President, Transcontinental & Western Air, Inc., New York, N. Y. Mem. A.S.M.E.

Contributed as a part of 1933 Progress Report of the Aeronautic Division and presented at the Annual Meeting, New York, N. Y., December 4 to 8, 1933, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

MAINTENANCE WORK ON AIR-TRANSPORT ENGINES AT TWA KANSAS CITY BASE

It is noteworthy that both the Boeing 247 and the "Condor" are bi-motored airplanes. In this respect the Boeing and the Curtiss-Wright companies have led the way toward replacement on a large scale of tri-motored aircraft with bi-motored aircraft, which type promises to be more efficient aerodynamically and more economical to operate. The Boeing 247 is powered with direct-drive supercharged Pratt & Whitney Wasps. The "Condor" is powered with geared unsupercharged Wright Cyclone F's.

These new transport aircraft, and others about to enter the field, have exhaustive wind-tunnel research (a large part of which was carried out by the National Advisory Committee for Aeronautics at its Langley Field Laboratory) to thank for the aerodynamic properties responsible for their improved performance. The investigation of wing-to-fuselage fillets, and the relation of engine nacelle fairings to the airflow over the wing, as conducted by the California Institute of Technology, have been productive of materially lower drag coefficients. Of special value have been the systematic researches made on wing-engine-propeller combinations as well as researches on engine cooling.

The year 1934 will bring forth other advanced types of aircraft. All these airplanes will have trailing edge flaps, and most of them will use controllable-pitch propellers. The new planes we can look forward to seeing next year are the General Aviation single-motored "GA-43," the General Aviation tri-motored "GA-38," and on the West Coast the Vultee high-speed single-engine transport and the Lockheed "Electra" multimotored transport.

The retractable landing gear has made its appearance on multiengined transport aircraft. This feature had already proved its value and dependability in use on smaller aircraft. It has been a foregone conclusion for several years that the old type of landing gear was costing altogether too much in cruising speed. The general method of retracting the landing gear is to draw it up into the combination engine nacelle, as in the Douglas transport, for example, or into the wing space immediately in back of the engines. The means of effecting the retraction and extension is a mechanical gearing, operated by an electric motor. An emergency hand-operated hydraulic mechanism is also provided. In one transport the drag coefficient, with the landing gear extended, is 85 per cent greater than when the gear is fully retracted. Landings can be made with the gear fully retracted without damage to the airplane other than to the propellers.

An important adjunct to the modern transport plane is the trailing edge flap. This consists of a part of the under side of the wing, forward of the trailing edge, being hinged and controlled by mechanism so that it can be lowered or brought back to the normal wing profile at the will of the pilot. This flap has two functions: It greatly increases the drag of the airplane (hence steepens the gliding angle) and increases the lift coefficient of the wing, thus producing a lower landing speed for a given wing area. In practise, this permits the use of thinner wing sections (hence faster) than heretofore, with less wing area, and yet the landing speed may be held to 60 mph.

With the greatly increased speed range, fixed-pitch propellers cannot be used because of reasons of safety and efficiency. The controllable-pitch propeller has arrived in time to permit full utilization of the aerodynamic cleanness of modern transports. The difficulty with the fixed-pitch propeller lies in the fact that if the pitch is set high enough to approach efficient high-speed operation (proper pitch for best cruising would be less efficient) the engines cannot turn up sufficient rpm's on take-off and the take-off characteristics of such an airplane thus become impractical. On the other hand, if the pitch is set low enough to allow a safe take-off, the moment the airplane is held in level flight the engine will race. The controllable-pitch propeller solves the problem. Two successful types are now in use. One uses the hydraulic principle to operate the mechanism which places the propeller blades in the lower pitch position necessary for take-off and climb. On this propeller the centrifugal action of counterweights places the blades in high pitch when the hydraulic pressure is relieved by a valve controlled by the pilot. Another type of controllable-pitch propeller uses an arrangement of worm and spiral gearing having an extremely high reduction ratio. Right-hand and left-hand spiral gears in the hub are brought respectively into contact with fixed worm gears attached to the crankcase of the engine when it is desired to increase or decrease the pitch. In this latter case propeller stops are used to throw the gears out of mesh and thus limit the range of pitch.

Another important stride made this year has been the successful development of the magnaflux method of testing hollow steel propeller blades. This, with the further improvement of the manufacturing processes of the hollow steel propeller blades themselves, holds forth hope to the aviation industry that it may soon have available propeller blades which will be even more satisfactory than the present duralumin types.

Supercharged engines play an important part in producing the high speeds of the new transports. It is well known that the higher the altitude at which an airplane flies, the greater

WORKING ON TRANSPORTS AT THE TWA KANSAS CITY MAINTENANCE BASE

the speed—providing the power output of the engines is held constant. This is due to the decrease in density of the air with altitude, and corresponding decrease in the drag of the airplane. A good example of the effect of using supercharged engines is the speed of a modern transport cruising at 75 per cent power; namely, 184 mph at sea level, 190 mph at 8000 ft, and 200 mph at 14,000 ft.

During the past year, two of the leading aircraft-engine manufacturers have placed in production single-row radial air-cooled engines rated at 700 hp at sea level and supercharged to corresponding powers at various altitudes. In the design and construction of these engines, full advantage has been taken of the commercial availability of fuels of higher octane number which permit the use of higher compression ratios and the application of a larger amount of supercharging, resulting in higher power output per cubic inch of displacement. Although the engine structure has been strengthened and stressed for the higher outputs, these engines have the lowest specific weight ever attained in production engines. They weigh only slightly more than 1.2 lb per hp. This figure is within two-tenths of a pound of the 1 lb per hp which the late Thomas A. Edison believed would be ideal in an aircraft engine.

Refinement in the design of superchargers to increase the efficiency and reliability of these units and the use of carburetors of larger air-intake capacity have also aided in the improvement of performance of aircraft engines at high altitudes.

The increased power per cubic inch of displacement and pound of weight, which characterizes the modern aircraft engine, has in no way impaired its reliability. On the contrary, present-day engines are more reliable than their predecessors. In addition, they are more economical to operate by virtue of their ability to operate for longer periods between overhauls, and the new design features which they incorporate facilitate routine maintenance.

There has been another important development which, although it does not influence performance directly, merits notice. This is the use of "trimming tabs" on the main control surfaces of the airplanes. The adjustable horizontal stabilizer of yesterday has been replaced by these "tabs" on the elevators. A similar control on the rudder counteracts the unbalanced engine force when flying with one engine out, and another such control on the ailerons takes care of any wing heaviness which may develop in flight. The adjustments for these three auxiliary controls are within reach of the pilot. It is probable that when extremely large airplanes become economically practical, their main controls will be operated in flight entirely by such auxiliaries. The pilot will operate the main surfaces directly only on take-off and landing maneuvers.

The attainment of increased performance has been realized with corresponding increase in passenger comfort. The specifications for new transports have rigidly prescribed a degree of passenger comfort hitherto unknown in airplane travel. Considerations of seating comfort, space for passengers to recline at practically full length, ventilation and heating, cabin illumination, visibility, and—most important of all—reduction of noise, have all received exhaustive investigation and corrective treatment.

Considerations of propeller efficiency and propeller noise have brought about the use of geared engines in transport aircraft. The high-pitch noise made by the tips of direct-drive propellers turning at about 2000 rpm has, in the past, thwarted the efforts of sound engineers to produce what might be termed a quiet passenger cabin. Geared engines favor the use of three-bladed propellers of less diameter than is usual with a two-bladed direct-drive propeller. The lessened diameter and the material decrease in rpm bring the actual tip speed down to around 700 fps, which is ideal from a sound standpoint, and also improves propeller efficiency under cruising conditions.

Effective soundproofing stands out as one of the greatest accomplishments achieved in the new transports. As a result of scientific study and an arrangement of sound rejecting and absorbing material, the passenger cabins have been made as quiet as the interior of a Pullman car. No small part of this is due to the fact that first of all the quality of the cabin sounds was analyzed in detail. Certain predominant notes were eliminated, and others were then blended to produce a mild, harmonious rumble which is in no way objectionable and does not interfere at all with conversation or even with music.

Wiley Post's recent successful solo flight around the world has attracted attention to the Sperry automatic pilot, upon which Post relied to share the strain of that grueling grind. It has long been recognized that landing and taking off constitute the major task of the pilot in flying. Straight flying for hours at a time is fatiguing at best. When instrument flying is necessary, the strain upon the pilot is increased. As a result, a pilot is rarely at his best when he comes in to land after a long flight. During the flight he has been unable to give his best attention to the use of the radio facilities or to the economical operation of the engines, or to navigation, because of having to fly the airplane continuously. Now comes the automatic pilot, which cares not whether the plane flies in sunshine, cloud, or storm.

It actually flies the airplane more smoothly than a pilot. It leaves the pilot free to concentrate on the navigation of the airplane and the handling of the engines. At the end of a flight the pilot is fresh, and he has had time, under bad weather conditions, to check his position carefully and plan his landing. The automatic pilot may prove to be a distinct step forward in air transportation.

The new Douglas transport, embodying all of the foregoing developments, has just successfully completed exhaustive flight tests and is now under service on the TWA system. This airplane promises to answer fully the demands of a traveling public which in the past few years has become most discriminating with respect to air travel. This transport will cruise at 190 mph and carry 14 passengers in a cabin 26 ft 4 in. long and 6 ft 3 in. high. The new type adjustable chairs offer the comfort of an overstuffed living-room chair. The noise level of the cabin is lower than that of a Pullman car. With transports such as these available, the already air-conscious public will accept air transportation as a comfortable, safe, and economical means of travel.

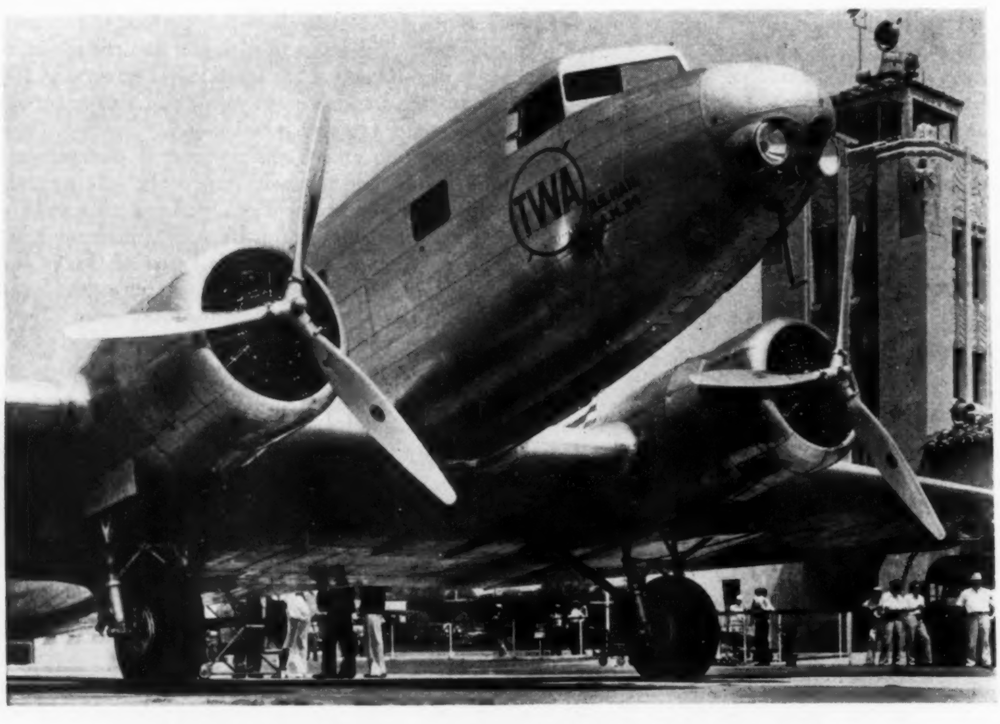
The railroads have for decades competed on the basis of routes. Airlines, on the contrary, are now entering a period of equipment competition. This may continue for five years or longer. However, based on our present knowledge of aerodynamics and construction, there are fairly definite limits to the speed of transport aircraft, the controlling factor being the final cost per mile of operation.

Airlines have improved the dependability of their operations during 1933. Three factors have been responsible. The first and most important of these has been instrument flying. The airlines now have all their planes equipped with the latest instruments to enable pilots to fly without reference to a true horizon. Chief among the instruments are the artificial horizon, the directional gyro compass, the turn indicator, and the sensitive altimeter. The radio range beacons of the Department of Commerce mark the airways and guide a pilot flying a radio-equipped plane with unerring accuracy. These invisible highways enable a pilot, flying only by instrument, to locate his destination and the airport at which he desires to land. Last but not least, there has been, during the last year, a great improvement in the science of meteorology and in the organization of the weather service throughout the country. Today, a pilot flying a radio-equipped plane may hear every 30 minutes a broadcast of the weather conditions along the route he is flying and on adjacent airways. He may also communicate at will with the ground stations of his own company.

The advancement of aeronautical meteorology has received tremendous impetus the last year through the practical application of the Norwegian, or Bjerknes, theory of forecasting (also known as the polar front system of weather forecasting). Research is being carried on in this work by the Massachusetts Institute of Technology and the California Institute of Technology, and its practical application to air-way forecasting is being carried out by three of the major airlines with gratifying results. The Federal Government can assist in this work materially by increasing the number of daily meteorographic airplane flights, as the successful application of the theory is dependent upon the accurate identification of the air-mass properties.

The progress of radio in airline operation has not been as spectacular in the last year as it was during the first few years after its application. Nevertheless, great technical improvements have recently been made in the equipment, and the airline personnel have come to regard its dependability as essential. The coordination of the flying, supervisory, and meteorological branches has become more highly developed through the use of two-way radio telephone during the last year than ever before. The airlines are just beginning to make practical use of blind landing devices, and it is confidently expected that this will improve the dependability of air transportation in periods of poor visibility.

During the last eighteen months, petroleum producers and refiners have become more and more interested in making available fuel and oil of higher quality. Crudes from which aviation gasoline is refined are being selected with greater care; refining practises are being continually improved, so that a fuel may be produced of high basic quality not requiring a maximum addition of tetra-ethyl lead to meet the demands of high-compression power plants. Many petroleum refiners are carrying out practical tests on contemporary service equipment, so that they may keep pace. An honest effort is being made to standardize test methods—since unusual operating conditions require specification petroleum products in the satisfactory operation of the modern up-to-date supercharged aircraft motor.



DOUGLAS TRANSPORT THAT RECENTLY FLEW WITH 12 PASSENGERS FROM LOS ANGELES TO NEW YORK IN 13 HOURS

HEAT-TRANSFER RATES *in* REFRIGERATING *and* AIR-COOLING APPARATUS

By W. J. KING[1] and W. L. KNAUS[2]

PRACTICALLY all forms of heat transfer are represented in the functioning of refrigerating and air-cooling apparatus. It would not be feasible to cover all of these processes in a paper of this kind. Excellent presentations of the generally available data may be found in such texts as Professor McAdams' treatise on heat transmission, the A.S.R.E. "Data Book" and the A.S.H.V.E. "Guide." The present paper will therefore be limited to two objectives: (1) To discuss the status of some of the more significant heat-transfer processes in the refrigerating field, and (2) to call attention to certain recent contributions to this subject which may not yet be generally familiar and accessible to most engineers.

There has been a tendency in the past for engineers to deal only with overall heat-transfer coefficients for combinations of several processes involved in a particular apparatus. There has been increasing evidence, however, that the advantages of dealing with individual coefficients or thermal resistances and segregating the factors affecting each process are being appreciated. The following discussion is therefore concerned principally with the basic heat-transfer mechanisms which are most common and significant in refrigerating apparatus. These are:

(1) Free convection
(2) Forced convection
(3) Evaporation
(4) Condensation.

Conduction and radiation are, of course, quite frequently involved but will not be included here because the data are generally available and adequate, for most purposes.

FREE CONVECTION

Although the process of heat transfer by free or natural convection is quite well understood,[3] the general formulas given for the film coefficient h are usually too cumbersome for convenient use. For conditions common to the field of refrigeration, the authors have found the following empirical formulas to be entirely adequate for practical purposes.

Let θ be the temperature difference in deg F; and h the film coefficient in Btu/hr/sq ft/F.

For vertical plane surfaces in still air,

$$h = 0.30\,(\theta/L)^{1/4} \qquad [1]$$

where L is the height in feet. The convection from a heated horizontal surface facing upward is about 30 per cent greater, and facing downward 30 per cent less, than in the vertical position. If the surface is cooler than the air, just the reverse is true.

For vertical or horizontal pipes in still air,

$$h = 0.42\,(\theta/d)^{1/4} \qquad [2]$$

where d is the pipe diameter in inches.

For bodies of ordinary sizes and shapes in unagitated water

$$h = 0.165\,(t_w + 30)\,\sqrt{\theta} \qquad [3]$$

where t_w is the water temperature in deg F.

It should be noted that radiation is ordinarily not involved in the exchange of heat between a surface and air or water, although it may be included in the heat-exchange with surrounding surfaces.

FORCED CONVECTION

Convection coefficients for air flowing over various surfaces are given in Fig. 1, based upon a considerable number of data collected from various sources in the literature. The curves for h are plotted against the linear velocity v for atmospheric air at 70 F and, in the case of tubes or pipes, for a diameter of one inch. The mass velocity[4] scale may be used for other temperatures and pressures ($G = v \times$ density in lb per cu ft); also, the effect of the tube diameter is shown in Table 1.

TABLE 1 EFFECT OF TUBE DIAMETER UPON FORCED CONVECTION COEFFICIENTS

Diameter, in.	0.1	0.25	0.5	0.75	1	1.5	2	4	8
	Multiply coefficient for one-inch tube by								
Flow inside tube......	1.59	1.32	1.15	1.06	1.0	0.92	0.87	0.76	0.66
Cross - flow, single tube	2.60	1.77	1.33	1.13	1.0	0.84	0.75	0.56	0.42
Tube-banks..	2.15	1.58	1.25	1.10	1.0	0.87	0.79	0.63	0.50

The two upper curves of Fig. 1 apply to staggered tubes; when the tubes are arranged in line the value of h is usually about 25 per cent lower.

In the case of finned tubes, the published data on the air-surface coefficients are very scarce and inadequate. In general, the indications are that finned-tube coefficients are approximately the same as those for plain tubes and vary in about the same manner with the air velocity and the tube diameter.

[1] Air-Conditioning Engineering Department, General Electric Co., Schenectady, N. Y.

[2] Engineering General Department, General Electric Co.

[3] See "Heat Transmission," by W. H. McAdams. McGraw-Hill, New York, 1933. "The Basic Laws and Data of Heat Transmission," by W. J. King, Mechanical Engineering, March, April, May, June, July, and August, 1932.

Presented at a session on heat transfer, under the joint auspices of the American Society of Heating and Ventilating Engineers, the American Society of Refrigerating Engineers, and the A.S.M.E. Process Committee at the Annual Meeting, New York, N. Y., December 4 to 8, 1933, of The American Society of Mechanical Engineers.

[4] In the case of tube-banks the value of G or v should be taken as the maximum velocity between the tubes, i.e., referred to the minimum free area rather than the face area of the bank.

Very recently T. E. Schmidt, of the Refrigeration Institute of Karlsruhe, has published a paper on "Heat Transfer in Air Coolers With Finned Tubes,"[5] which includes data on the air-film coefficient h. These have been converted to English units and plotted in Fig. 2, where h is based on the total external surface, including fins. The numbers on the curves refer to the

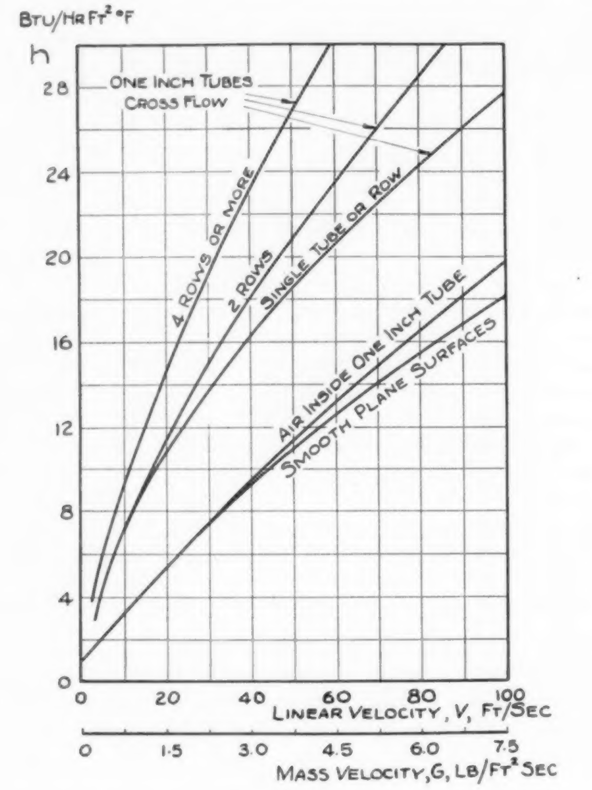


FIG. 1 HEAT-TRANSFER COEFFICIENTS FOR AIR AT ONE ATMOSPHERE AND 70 F

five different coolers tested, the dimensions of which are given in Table 2.

TABLE 2 DIMENSIONS OF COOLERS TESTED

Cooler no.	1	2	3	4	5
Number of rows	6	6	8	8	8
Tube diameter, in.	3	3	1.5	1.5	1.5
Fin diameter, in.	7	7	5.5	5.5	5.5
Fins per ft	15	9	15	12	10
Fin surface/tube surface	10	5.77	15.65	12.5	10.35

In all cases the tubes were of steel and the fins were of iron, 0.040 in. thick, zinc-dipped to insure a good bond with the tube. The tubes were arranged in line, two rows wide and six or eight rows deep.

Unfortunately, these tubes are somewhat larger than those commonly employed for air cooling in this country, where copper fins are generally used instead of iron, and, as already mentioned, the arrangement of the tubes in line gives lower coefficients than when the tubes are staggered. The values of h shown in Fig. 2 are accordingly lower than those given in Fig. 1 for plain tubes.

In view of the widespread use of finned tubing in air-cooling and heating apparatus, there is an urgent need for more information on this subject. It is particularly desirable that experimental work should be conducted so as to obtain individual surface coefficients instead of simply overall coefficients for special combinations of conditions.

EFFECT OF DEHUMIDIFICATION UPON CONVECTION COEFFICIENTS

So long as the temperature of the cooling surface does not go below the dewpoint of the air, the effect of humidity upon the convection coefficient is negligible. On the other hand, when the air is dehumidified as well as cooled, the latent heat of condensation is added to the sensible heat transferred. Although the condensation of moisture is governed by the vapor-concentration difference, it has been shown by Merkel[6] that the effect of the latent heat may be included in a total heat transfer coefficient h', referred to the temperature difference, which is related to the ordinary coefficient for sensible heat transfer h, as follows:

$$h' = h\left[1 + \frac{4500\,(c - c_s)}{t - t_s}\right] \text{ Btu/hr/sq ft/F} \ldots\ldots [4]$$

or

$$h' = h\,\psi'$$

where c is the moisture concentration in the air stream at the temperature t, and c_s is the moisture concentration of saturated air at the cooling surface temperature t_s. Concentrations are in pounds of moisture per pound of dry air and temperatures are in deg F. The "humidity factor" ψ', which represents the bracketed term in formula [4] can be computed easily from data taken from a psychrometric chart for the operating condi-

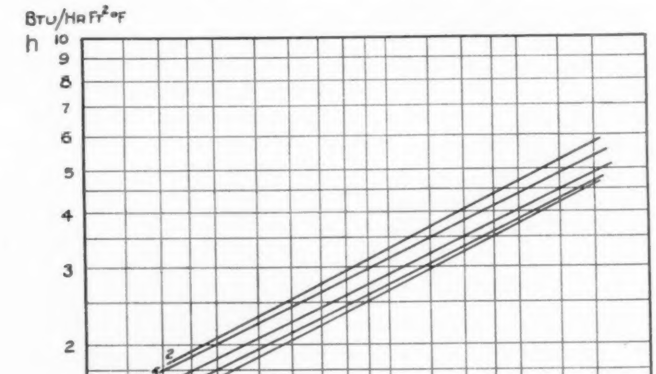


FIG. 2 AIR-SIDE COEFFICIENTS FOR FINNED TUBES

tions, using mean values of c and t. For example, if air at a mean temperature of 80 F and a mean relative humidity of 60 per cent passes over a cooling surface at 40 F, $(c - c_s) = 0.0077$, $(t - t_s) = 40$, and $\psi' = 1.87$, or $h' = 1.87\,h$.

Formula [4] is based on the relation derived by Lewis[7] between the heat transfer coefficient and the diffusion coefficient for water vapor in air. Hase[8] has recently reported some ex-

[5] "Der Wärmeübergang in Luftkühlern mit Rippenrohren," by T. E. Schmidt. Beihefte zur *Zeitschrift für die Gesamte Kalte-Industrie*, series 2, part 6, 1933.

[6] "Der Wärmeübergang in Luftkühler," by F. Merkel, *Zeitschrift für die Gesamte Kalte-Industrie*, 1927, no. 7, p. 118.

[7] "The Evaporation of a Liquid Into a Gas," by W. K. Lewis, MECHANICAL ENGINEERING, 1922, p. 445.

[8] "Versuche über den Wärmeübergang in Luftkühler," by G. Hase, *Zeitschrift für die Gesamte Kalte-Industrie*, 1933, no. 10, p. 149.

perimental work on heat transfer with dehumidification in which he examines the effect of the temperature drop through the surface water film, and computes values of the Lewis ratio from the amounts of sensible heat and moisture transferred. He obtains appreciably lower ratios than that predicted by the theory, but the accuracy of his test data appears somewhat questionable.

Piening[9] has derived an elaborate general formula for the humidity factor ψ' in the case of free convection to plane surfaces and pipes, which he finds to be in good agreement with his experimental data. By substituting appropriate values for the properties of air, his formula may be shown to be identical with formula [4] under the conditions encountered in ordinary air-cooling applications. It appears, therefore, that under normal conditions formula [4] should be applicable to any type of convection problem involving plain, unfinned surfaces.

In the case of finned tubing, however, the problem is more complex, due to the effects of the radial temperature gradient

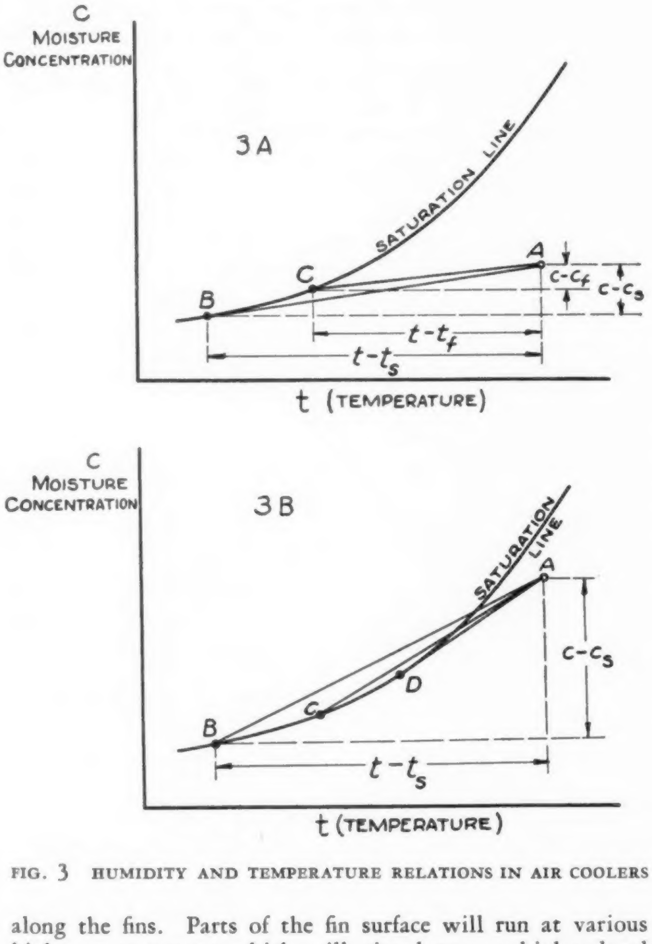


FIG. 3 HUMIDITY AND TEMPERATURE RELATIONS IN AIR COOLERS

along the fins. Parts of the fin surface will run at various higher temperatures which will give lower or higher local values of ψ than that of ψ' calculated for the tube temperature, to which the coefficient h is referred. This may be seen by reference to the curves of Fig. 3, which represent conditions on the psychrometric chart. In both curves point A represents the temperature and humidity of the air, point B the tube temperature, and point C the mean fin temperature. It may be seen that the slope of the line A–B determines the value of ψ' in formula [4], while the slope of the line A–C governs the effective value of ψ for the fins. When ψ' is small (Fig. 3A) the slope of A–C is less than that of A–B so that the integrated value of ψ for the total fin and tube surface is less than ψ'. On the other hand, when ψ' is large (Fig. 3B), A–C may have a greater slope

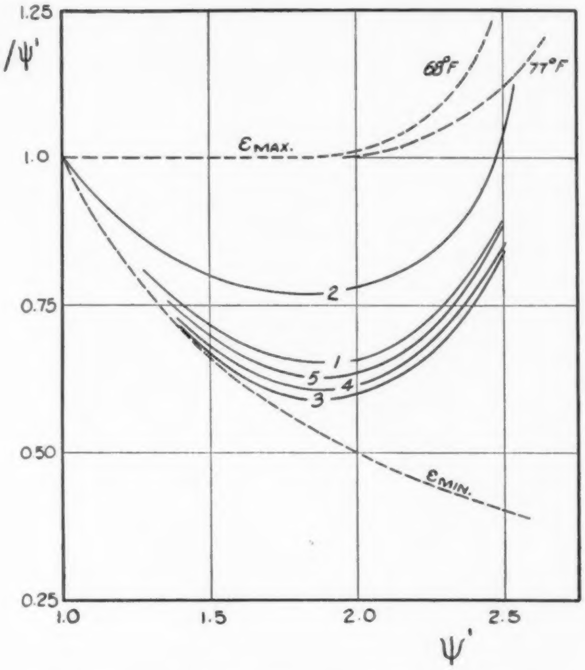


FIG. 4 VALUES OF ϵ FOR VARIOUS TYPES OF FINNED TUBES, ACCORDING TO T. E. SCHMIDT

than A–B, or the humidity factor for the fins may be greater than that of the tube. In this case the maximum value of ψ for any fin temperature must be limited by the slope of the line A–D, drawn from the point A tangent to the saturation line.

This problem has been studied theoretically and experimentally by Schmidt in the paper[5] referred to. From a series of tests with tube temperatures below the dew-point he obtains a relation between ψ_R, the empirical value of the humidity factor for the finned tubes, and ψ', its value computed from formula [4] taking t_s as the tube temperature. He finds that the ratio

$$\psi_R/\psi' = \epsilon$$

depends chiefly upon the value of ψ' and the ratio of the fin surface to the tube surface. His results for the five coolers previously described are shown in Fig. 4, in which the numbers on the curves are those of the coolers.

In these tests the air velocity was varied from 3 to 30 ft per sec, but in all cases the tube temperature was 37 F and the air temperature was in the neighborhood of 70 F. Apparently the value of ϵ is not appreciably affected by the air velocity, and, as Schmidt points out, the characteristic shapes of the curves will be the same for other air and tube temperatures. The procedure for adjusting the curves to other temperature conditions is indicated by the following considerations:

The dotted curves $\epsilon_{min.}$ and $\epsilon_{max.}$ in Fig. 4 show the minimum and maximum values of ϵ between which the curves must lie. $\epsilon_{min.}$ is simply a plot of $1/\psi'$, since h' can never be less than h. $\epsilon_{max.}$ is obtained from the ratio ψ_R/ψ' by substituting

[9] "Der Wärmeübergang an Rohren bei freier Strömung unter Berücksichtigung der Bildung von Schwitzwasser und Reif," by W. Piening, *Gesundheits-Ingenieur*, 1933, no. 42, p. 493.

the maximum value of ψ_R which may be obtained from the expression

$$\psi_R = \left[1 + \frac{4500\,(c - c_f)}{t - t_f}\right] \ldots\ldots\ldots\ldots [5]$$

for any position of the point C in Fig. 3. For low values of ψ' (Fig. 3*A*), ψ_R cannot exceed ψ', since *A–C* cannot have

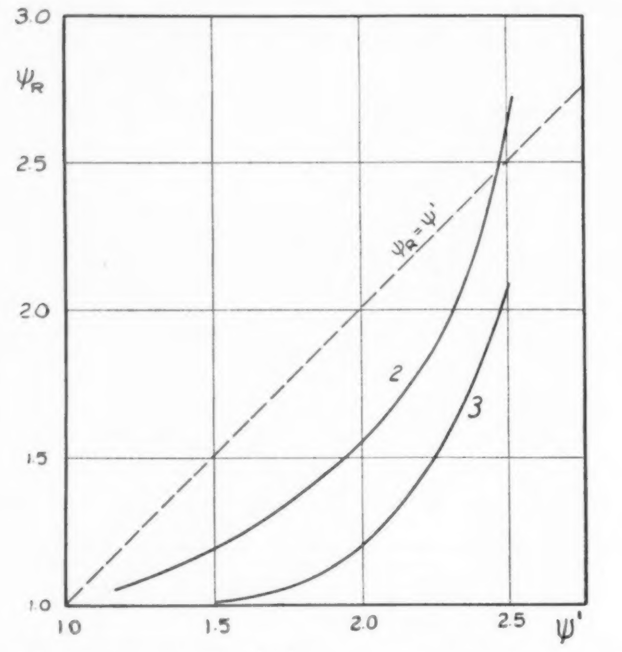


FIG. 5 HUMIDITY FACTORS (ψ_R) FOR TWO OF THE TUBES OF FIG. 4

a greater slope than *A–B*, and hence $\epsilon_{max.} = 1$. At high values of ψ' (Fig. 3*B*), the slope of *A–C* may be greater than that of *A–B*, or $\psi_R > \psi'$ and $\epsilon > 1$. From these considerations it follows that $\epsilon_{max.}$ will first exceed unity when ψ' is increased to the point where the line *A–B* cuts the saturation line. In Fig. 4 this condition occurs when $\psi' = 1.85$, which is also the point at which curves 1 to 5 reach their minimum values and begin to turn upward. To adjust the curves of Fig. 4 to any other temperature conditions it is therefore necessary only to compute the value of ψ' at which $\epsilon_{max.}$ first exceeds unity and then displace the abscissas of all of the points proportionately in the ratio of this value to 1.85. For example, if the air temperature is 80 F and the tube temperature is 50 F, $\epsilon_{max.}$ can exceed unity when ψ' exceeds 2.28; i.e., when the relative humidity exceeds 75 per cent. Under these conditions the points on Fig. 3 should be shifted along the ψ' axis in the ratio 2.28/1.85, or the values of ϵ should correspond to values of ψ' 1.23 times those given.

In Fig. 5, curves 2 and 3 of Fig. 4 have been replotted to show the effect of the conditions represented by ψ' upon the experimentally determined humidity factor ψ_R for the finned tubes. It will be observed that the tube having the smallest ratio of fin area to tube area (curve 2) showed the highest humidity factors, which were higher than the factors for plain tubes (indicated by the line $\psi_R = \psi'$) when ψ' exceeded 2.47.

The significance of these results is indicated by the fact that the effective heat transfer coefficient h' under some conditions of humidity and temperature may be more than double the ordinary coefficient h for sensible heat transfer. Because of the inadequacy of the ordinary data for the commonly used types of finned tubing, it appears that this method could be used to advantage in future analyses of air-cooling data.

EVAPORATION

The available information on heat transfer from metallic surfaces to boiling liquids is far less satisfactory than that of the other processes of heat transmission. This arises from the large number of variables which affect the process, and because its fundamentals are not thoroughly understood. Only a start has been made in attempting to correlate data for evaporation by dimensional relations, so useful in the study of convection.

For liquids boiling without forced circulation, the coefficient increases rapidly with the temperature difference. This seems to be due to the more rapid circulation of the liquid as the boiling becomes more vigorous with increasing temperature difference. Where a rapid rate of circulation is maintained by mechanical or other means, the coefficients are found to be high and but little affected by the temperature difference between the surface and liquid.

Where conditions are such that the liquid superheats easily, the coefficients are likely to be low and the evaporation erratic. This condition can be remedied by any means that stirs up the liquid and starts the process of bubble formation.

The condition of the surface is also of great importance.

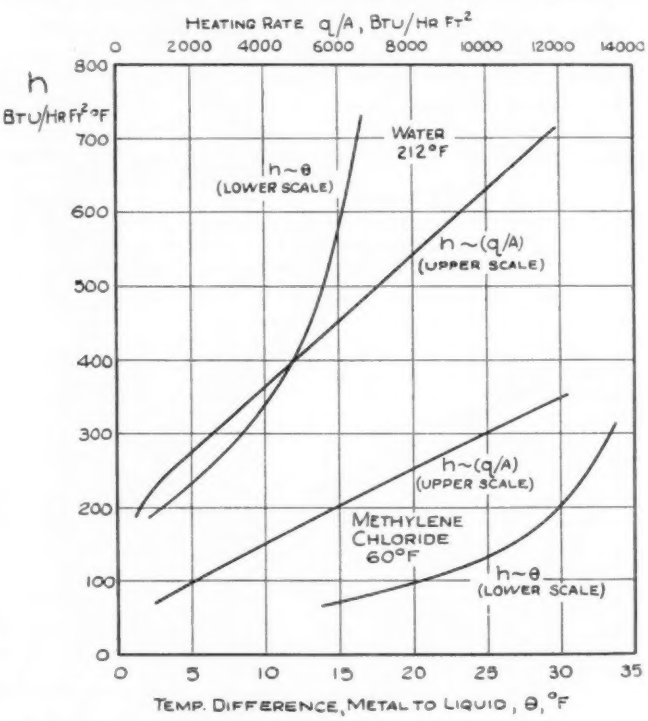


FIG. 6 HEAT-TRANSFER COEFFICIENTS OF BOILING LIQUIDS

Roughened or grooved surfaces lead to higher coefficients than those obtained with smooth polished surfaces.

Fig. 6 shows representative evaporation coefficients for water and methylene chloride. The data for water are also typical of what may be obtained with ammonia in refrigerating practise. Ammonia coefficients are higher than for any other refrigerant and may be regarded as establishing an upper limit. The curves for methylene chloride are typical of a large number of organic refrigerants. Coefficients for sulphur dioxide are likely to have intermediate values between the two sets shown. The plots of the heating density (q/A) against the coefficient h are of interest in more clearly showing the trend of the co-

efficient than is done by the rapidly rising graphs of h vs. θ.

Cryder and Gilliland[10] have given the results of tests in which eleven different liquids were boiled at atmospheric pressure, and have correlated their results in terms of the fluid properties. Their expressions have at least qualitatively accounted for the enormous rate at which the evaporation coefficients for water increase with increasing boiling point.[11]

CONDENSATION

Studies of the process of condensation have led to a fairly complete understanding of the factors which are involved. Where a *pure* saturated vapor is condensing, Nusselt[12] has given the following expressions for condensing coefficients.

For a vertical surface of height L feet,

$$h = 105\left(\frac{r\rho^2k^3}{ZL\theta}\right)^{1/4} \qquad [6]$$

For a horizontal pipe of diameter D inches,

$$h = 152\left(\frac{r\rho^2k^3}{ZD\theta}\right)^{1/4} \qquad [7]$$

where r is the latent heat in Btu per lb, ρ is the density in lb per cu ft, k is the thermal conductivity of the condensate in Btu/hr/sq ft/(F/ft), Z is the viscosity of the condensate in centipoises, and θ is the temperature difference between surface and vapor in deg F. Where horizontal tubes are arranged vertically over one another, D should be taken as the sum of the diameters in a vertical row. These formulas have been found fairly reliable for conditions encountered in refrigerating condensers, but will predict results too high if considerable amounts of non-condensing gases are present.

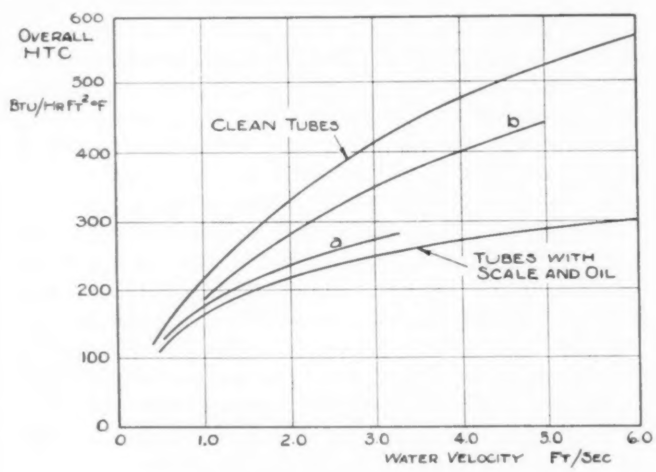


FIG. 7 STRAIGHT-PIPE CONDENSERS

Linge[13] has recently made a comparison of condensers of various types based upon both his own and other tests. Fig. 7 shows the overall coefficients from ammonia vapor to cooling water for straight pipes of average size, in which water is flowing within the tubes and ammonia is condensing on the exterior. Curve b is from the tests of Kratz, Macintire, and Gould on a multitube condenser,[14] while curve a applies to a double-tube condenser of a German firm. The boundary lines have been calculated from the individual coefficients for water and ammonia, and the conductivities of the steel pipe, scale, and oil film. The actual curves a and b conform quite well, in their general shape, to the calculated ones.

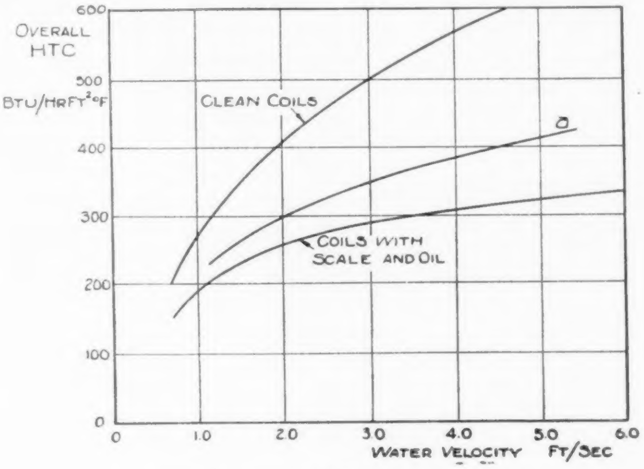


FIG. 8 COILED-PIPE CONDENSERS

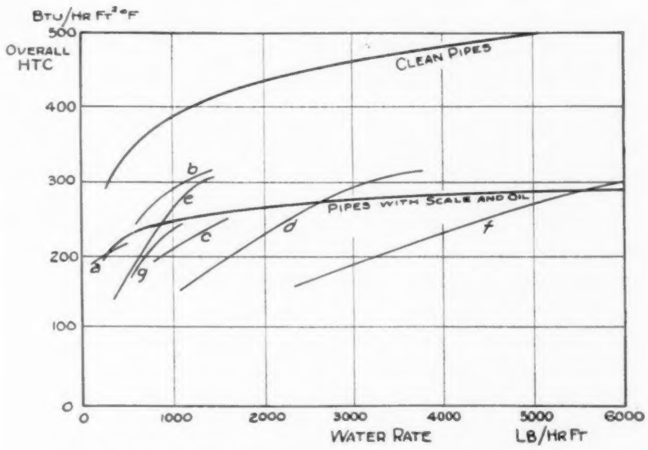


FIG. 9 DRIP AND ATMOSPHERIC BLEEDER CONDENSERS

Fig. 8 gives similar curves for coiled-pipe condensers, with water flowing in the tube and ammonia condensing outside, as in the previous case. The limiting curves were calculated for a coil having a ratio of tube to coil diameter of 1:8, and are somewhat higher than those in Fig. 7 because of the slightly better heat transfer from water to tube wall. Here the curve a applies to a condenser of German manufacture of this type.

Fig. 9 again gives calculated and actual performance curves for condensers of the drip and atmospheric bleeder types. In this class the calculations do not seem to predict the variation of the overall coefficient with the water flow as well as in the previous cases. Curves a, b, and c are for equipment made by German firms, whereas d is from the tests of F. R. Zumbro,[15] e from the work of A. H. Horne,[16] and f is from Kratz, Macintire, and Gould.[17]

(*Continued on page 304*)

[10] *Refrigerating Engineering*, vol. 25 (1933), p. 78.

[11] In the discussion of the last-mentioned paper some tests, showing a hundredfold variation in the coefficient for water boiling at 212 F, as compared with that at 60 F, are reported for the same apparatus and equal temperature differences in the two cases.

[12] W. Nusselt, *Zeitschrift des Vereines deutcher Ingenieure*, vol. 60 (1916), p. 541.

[13] K. Linge, *Zeitschrift für die Gesamte Kalte-Industrie*, vol. 40 (1933), pp. 81–84, 108–112.

[14] Univ. of Ill. Engrg. Exp. Sta., Bull. No. 209, 1930.

[15] *Refrigerating Engineering*, vol. 13 (1926), p. 49.

[16] *Refrigerating Engineering*, vol. 9 (1922), p. 9.

[17] Univ. of Ill. Engrg. Expt. Sta., Bull. No. 186, 1928.

MECHANICAL ENGINEERING

Vol. 56 MAY, 1934 No. 5

GEORGE A. STETSON, *Editor*

The Engineers' Code

IT HAS been the intention to keep readers of MECHANICAL ENGINEERING informed as to the status and content of that chapter of the Construction Code which deals with professional engineering in the construction industry. This is the only code so far developed under the NRA that applies specifically to the profession of engineering, although, of course, engineers will find that the industries in which they are employed are complying with many others. Numerous drafts of the code for the engineering division of the construction industry have been made and one is at present undergoing study and revision. At the present writing it is impossible to predict when and if it will be signed. Under the circumstances, therefore, it is inadvisable to publish the proposed draft of the code or even to summarize it, although copies of it should be available by the end of April for those who wish to study it.

It should be emphasized once more that the code does not apply to individuals but to employers who perform engineering services in competition with others in connection with the construction industry. It should also be emphasized that the code is not sponsored solely by the American Society of Civil Engineers although, for obvious reasons, that society has taken initiative and has played a leading rôle in drafting it, and is to be charged with the appointment on the proposed code authority of more members than any other group. The interests of mechanical engineers in the drafting of the code are guarded by the A.S.M.E. representative, Henry C. Meyer, Jr., of New York.

Engineering Societies Employment Service

ASSURANCES from many trustworthy sources that business conditions are getting better have, as yet, been accompanied by no mad scramble to secure men to fill jobs. Unemployment is still the most important of the numerous vital problems facing the country, and unemployment among engineers continues to be a consequence of this universal distress.

In the Engineering Societies Employment Service, with its offices in New York, Chicago, and San Francisco, there exists a clearing house of jobs and men that both employer and unemployed engineer patronize with profit. It is maintained by engineers for engineers. During the depression it has been working heroically to make the best of a discouraging situation. It has brought renewed courage to many a man facing economic disaster. Naturally it has been unable to place all applicants, but statistics show that in 1933 there were 2430 men registered and 870 placed. As recovery advances and the demand for men becomes universal, employers will be able quickly to put their hands on engineers to meet their needs by making use of the Engineering Societies Employment Service.

Junior Study Groups

ATTENTION was directed last month to the necessity of maintaining a virile and progressive engineering society by providing work for junior members and encouraging their participation in activities related to their own needs and interests. In this connection the success with which groups of junior members in the Metropolitan section of the A.S.M.E. have been following certain programs of study offers convincing proof of the value of these studies and should stimulate young men in other parts of the country to engage in similar activities.

One of the groups organized in the Metropolitan section in 1933 successfully completed a course of study in structural engineering, having in view the examinations in this subject which must be passed by all engineers applying for a license to practise engineering in the State of New York. The examination is an especially rigorous requirement of the licensing procedure of the state, but with the training provided by the study class, all members of the group passed it successfully. This has led to the formation of other groups, one of which is at present preparing its members for the state examination in June. J. A. Lind is in charge of this group.

Other groups in which studies are being pursued, and the leaders, who are all junior members of the A.S.M.E., are as follows: Finance and accounting, in which an attempt is made at a broad survey of the field with special emphasis on the phases of it which an executive must know in order to interpret a balance sheet, Lloyd F. Kniffin, leader; the fundamentals of physical chemistry and their practical application to industry, John Ware, leader; and literature and modern thought, specifically guided by the booklist prepared by the committee on guidance of the Engineers' Council for Professional Development, Arthur Sterns, leader.

At certain meetings of these groups lecturers from the local universities and others who have special attainments in the branch of studies involved are invited to lead the discussion. The fact that the groups, which are relatively small, are made up of earnest young men intent on adding to their formal education by discussion and study with others of their same age and interests is important from a social point of view.

The plan which the junior members of the Metropolitan section are pursuing so successfully should be put into operation in every locality where there are enough young men interested in a common problem to make a

study group a success. Older members can be looked to to provide encouragement and cooperation in leading discussion when their knowledge and experience guarantee that they are competent, but the inspiration and enthusiasm to carry the group through a course of study to a reasonably successful finish can only come from the juniors themselves.

Every local section of the A.S.M.E. will be augmented in the fall by several of the 1400 student members that are being graduated in June. What better way is there to arouse and maintain the interest of these young men and to convince them of the value of the A.S.M.E. than to encourage them to organize study groups in cooperation with other junior members of the section?

Lubrication in Engineering Schools

RECENT announcement of a special course of lectures at Brown University by Mayo D. Hersey on the subject of lubrication calls to mind the possibility that engineering schools in general may have been failing to pay sufficient heed to an important factor in machine design and maintenance.

It is now half a century since Osborne Reynolds applied the principles of hydrodynamics to the problem of lubrication. During those fifty years, working independently but simultaneously, Kingsbury in this country and Michell abroad advanced our knowledge of that wedge-shaped film of lubricant which forms between two surfaces that are parts of a shaft, or other member, and its bearing, and led the way to a theoretical study of the various factors that should be considered in bearing design and to the redesign, along rational lines, of these important elements of machines. At the same time our knowledge of the chemical and physical properties of lubricants has accelerated rapidly and the significance of such factors as viscosity has begun to have meaning to those who operate machinery. The use of high-speed machinery, with heavy bearing loads and extreme temperature conditions, and the supreme importance of continuity of service and careful handling of expensive machines in which the elimination of as much as possible of the waste of power due to friction is an item to be considered, have prodded engineers into scientific investigations of all phases of lubrication. Even such portions of the general subject as relate to the use of lubricants in cutting and forming metals are being subjected to determined attack with a view to the effect on tools and work, and on the economics of production.

Naturally, the literature of The American Society of Mechanical Engineers is rich in studies of lubrication, contributed by individuals and by special committees that the Society has set up to concern themselves with the various phases of this important subject. It is gratifying that some of this material is finding its way into the handbooks and textbooks used in our engineering colleges; and that, as, for example, in Professor Norton's course at Harvard, attempts are being made to place the emphasis on the subject that its economic importance warrants. The days have gone when a drill hole at some convenient point in a bearing cap, as likely as not wrongly located, and provided as an afterthought by the machine designer, or some grooves scraped into the soft babbitt by a geometrically minded mechanic, or oil, unspecified as to properties or amount and administered by an unreasoning oiler, can be tolerated. The place to begin the intelligent consideration of these matters is in the engineering-school curricula where at least the fundamental principles can be incorporated as vital parts of courses relating to machinery.

It is safe to say that our knowledge of lubricants and lubrication is still incomplete. Such contributions to that knowledge as are brought to the attention of engineers must be accorded unbiased and sympathetic scrutiny, and, if they are found to be sound and valid, passed on to designers, machine operators, and the engineering schools as additions to, or modifications of, our understanding of the subject. It is by such methods that engineering advances and engineering societies are justified.

Questions to Answer

THE PLIGHT of the durable-goods industries is of vital concern to the country at large but especially to mechanical engineers. Colonel Ayers has shown, for example, that of 12,266,000 workers unemployed in the summer of 1933, 5,680,000 were producers of durable goods while only 538,000 were producers of consumption goods. When it is realized that in 1929 there were nearly 16 million producers of consumption goods and nearly 10 million producers of durable goods, the unemployment figures take on even greater significance. It is safe to say that if employment in the durable-goods industries could be restored to normal levels, the 5,868,000 providers of services who were also out of work in the summer of 1933 would find plenty to do.

It is not intended to discuss here the factors that are retarding recovery in these important industries. They are many and complex. But engineers and the country at large should have a comprehension of the important social and economic rôle played by the durable-goods industries. The economic characteristics of these industries are fairly well known and business and social policies based on them would seem to be one form of possible and prudent planning. In the process of study and in the development of the policies, there are many important questions that should be thoroughly aired. There has been much dogmatic talk about overproduction and overcapacity, the necessity and desirability of government regulation of funds going into investment, redistribution of wealth by taxing the profits of industry, technological unemployment, and the relative claims of wages and dividends, to mention a few. Until these and other questions are answered, it will be difficult to set up a uniformly acceptable political philosophy with respect to our economic and social life and the durable-goods industries. Mechanical engineers as individuals and as a group should not shirk their portion of the burden of setting up the philosophy.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

Plywood and the "Flivver" Airplane

THE Department of Commerce by its questionnaire recently attracted a good deal of attention to the so-called "Flivver" airplane described by F. R. Neely, of the Department of Commerce, in a meeting, January 17, 1934, of the Society of Automotive Engineers and the Aircrafters, in Philadelphia, as an airplane of general usefulness to sell at present-day automobile prices. It was the hope of the department that the price of $700 could be met for a small two-passenger airplane. $500,000 has been set aside from present funds to be used in "tooling up" a plant for the production of such an airplane.

At a selling price of $700 this airplane would cost about 50 cents per pound. Present-day automobiles are built on a production basis and after years of experience cost about 35 to 40 cents per lb. This comparison has to be taken, however, with a reservation, because the automobile has more parts in it than an airplane and no consistent effort has been made to keep the automobile weight low.

There is information to indicate that the British have designed a light airplane to sell for about $500. Plywood has the required size and strength properties for a small airplane and does not have to be made so thin as to introduce danger from corrosion and failure from local buckling. Due to its low weight, plywood can be used so as to eliminate local failures, give rigidity and "crashproofness," and carry the low loads imposed on a small plane. In this connection the author calls attention to the fact that the ability of plywood to lend itself to mass production has never been properly exploited, but the experience of the builders of the Lockheed line of airplanes indicates some of the possibilities of molding or pressing whole sections of the airplane on a mass-production basis.

The tentative specifications set up by the Department of Commerce include an "all-metal" construction requirement, but this may be modified. The author claims that despite the all-metal specification, it is becoming increasingly apparent that the wing and fuselage covering to secure a satisfactory weight efficiency cannot be of metal, and plywood possesses decided advantages from every point of view over fabric-covered metal construction. (R. R. Weise, *Veneers and Plywoods*, vol. 28, no. 3, March, 1934, pp. 10–11, *d*)

APPLIED MECHANICS

The Buckling of Thin Plates in Compression

THE strength of construction in thin sheet metals that are now being used to a large extent by aircraft manufacturers is often considerably affected by instability of parts of the structure. The present paper describes an investigation by both theoretical and experimental methods into the influence of buckling on the strength of rectangular plane panels of thin sheet metal subjected to compression parallel to one pair of edges.

Theoretical analysis of the behavior of panels both before and after buckling is developed and the results are compared with the results of tests on panels with two different types of edge support.

The results of the experiments carried out to check the theoretical conclusions provide reasonable confirmation of the relation between stress and strain as determined theoretically. The collapsing load of a panel of width $2d$, thickness $2h$, and height greater than $4d$ is shown theoretically to be equal to the crushing load of a similar panel of width $2d'$, where $d' = Lh + Md$, the values of L and M depending upon the crushing strength of the material and upon the edge-fixing conditions, and the term Lh being normally considerably greater than the term Md. The collapsing loads recorded in actual tests are shown to be in reasonably good agreement with this theoretical formula. (H. L. Cox, from summary of Reports and Memoranda, No. 1554, Aeronautical Research Committee, 1933, *te*)

ENGINEERING MATERIALS (See also Aeronautics: Plywood and the "Flivver" Airplane)

Kunial Copper Alloys

THIS is a series of brasses, nickel silver, and bronzes developed in England. The main feature of these alloys is that while they can be extruded, rolled, drawn, and cold-worked like ordinary copper alloys, their hardness may be trebled, their tensile strength doubled, and their other mechanical properties considerably improved by a simple heat treatment. The analyses of the materials are not given so that it is not shown what produces these properties. Neither is the method of heat treatment stated. The author of the article, after giving the figures for the mechanical properties, calls attention to the fact that in a paper presented to the Institute of Metals in Birmingham in September, 1933 (*Engineering*, Vol. 136, 1933, p. 695), Dr. H. W. Brownsdon, Dr. M. Cook, and H. J. Miller have given values of physical properties for one of their alloys bearing a striking resemblance to those now quoted for the Kunial alloy. This alloy was then said to contain 72.5 per cent copper, 6.0 per cent nickel, 1.5 per cent aluminum, and 20 per cent zinc. Doctor Brownsdon and his staff have developed the Kunial alloys in the Research Laboratories of I.C.I. Metals, Ltd., Witton, Birmingham, England. (*Engineering*, vol. 137, no. 3553, Feb. 16, 1934, pp. 175–176, *d*)

FUELS AND FIRING

The Distinction Between Anthracites and Semi-Anthracites of Pennsylvania

THE coals mined in the area known as the anthracite fields of Pennsylvania have always been recognized commercially as anthracites. In the literature, however, some of the anthracites have been called semi-anthracites by various writers. The coals mined in Sullivan County, and especially those from the Bernice fields, have been recognized commercially both as anthracites and semi-anthracites. In the literature

they almost always have been referred to as typical semi-anthracites, although Franklin Platt, in his report to the Pennsylvania Geological Survey, uses the terms semi-bituminous, semi-anthracite, and anthracite in describing them. The purpose of this paper is to endeavor to dispel the confusion of names used to describe these coals and to supply information which will permit a logical and definite classification.

The author constructed a map showing lines of equal volatile matter and lines of equal specific gravity throughout the anthracite and semi-anthracite regions. He then considers the various properties as a means of distinguishing between the two types and comes to the conclusion that physical properties alone, while serving to distinguish between many anthracites and semi-anthracites, fail when applied to borderline coals. He also finds that there is a lack of relation of volatile matter to friability. In general, semi-anthracites are more friable than most anthracites, but friability cannot be used to define borderline cases. As regards specific gravity, the apparent gravities are of more practical value than the true gravities. Tests indicate that, of the coals tested, all the anthracites are 1.40 and higher on the moisture and ash-free basis, and all the semi-anthracites are 1.40 and lower. One anthracite, however, has 91.6 per cent free carbon as compared to 91.5 for a semi-anthracite. The author suggests, therefore, 92.0 per cent free carbon as a logical boundary figure. This figure of fixed carbon is also justified by the closed-tube test, which is important in itself.

Analyses of a number of coals from various fields are given in the original article.

The author gives what he considers to be a final classification of the anthracite group and states that coals between 91.5 and 92.0 fixed carbon are anthracites if they do not yield tar in the standard closed-tube test. There are, however, a few coals which are not quite covered by this classification. Such cases, however, are rare. (Paper before the February, 1934, meeting of the American Institute of Mining and Metallurgical Engineers, by Homer G. Turner, State College, Pa., 10 pp. of mimeographed matter and one map, *p*)

HYDRAULIC ENGINEERING

Hydraulic Turbine for Gas-Charged Water

THIS turbine has been designed by the English Electric Co., Ltd., for the I.C.I. (Fertilizer & Synthetic Products, Ltd.) for use with gas-charged water at a chemical plant in South Africa. The water to be used for generating power is delivered subsequently to its use in a chemical process under a head of 1700–1870 ft at a rate of about 477 gal per min. It contains from six to ten times its own volume of gas in solution, and it was required that the turbine should extract the energy and discharge the mixture of gas and fluid to a height of 67 ft. The high head, of course, meant that the turbine must be of the impulse type, but the difficulty at once suggested itself that, owing to the drop of pressure as the water passed through the nozzle, the gas would no longer remain in solution. It was feared that the liberation of the gas in very large quantities would necessarily break up the jet into a spray from which no useful work could be obtained. A theoretical investigation of the matter, however, suggested that these fears were unfounded, and nozzle experiments carried out by the customers at the Billingham works proved that by the use of a properly shaped nozzle and suitably designed buckets, the pressure energy of the water could be converted, first, into velocity energy of the jet, and then into mechanical work so rapidly that the gas, in fact, had no time to come out of solution and had, therefore, no harmful effects. This is shown by illustrations in the original article.

As far as the question of the exhaust against a head of 67 ft was concerned, the problem was met by causing the gas pressure to do the work. The inlet and discharge pipes and the casing of the turbine are so arranged that the latter is always completely full of the gas liberated by the water on its way through the turbine, and the pressure of this gas forces out the fluid discharged by the wheel.

The final design adopted is now working satisfactorily on site in South Africa; the impulse turbine runs at a speed of 1000 rpm.

The runner has buckets of a mild-steel alloy of a composition making it highly resistant to the gas-charged water. To secure homogeneous material the buckets were stamped instead of being cast. They have accurately shaped splitter edges for dividing the jet without shock and highly polished surfaces to minimize friction losses and prevent wear. The English Electric Company's patented one-bolt bucket fastening, described in the original article, is used.

The runner is overhung, being carried by the generator-shaft extension. Where the shaft passes through the water-cooled pressure gland of the turbine casing, it is sleeved with stainless steel. The axial force due to the action of the pressure inside the casing on the cross-sectional area of the shaft is taken up by the ball thrust. The streamlined inlet bend feeding the turbine has a nozzle controlled by a hand-operated spear. Both are of stainless steel, suitably polished. A ring of axial guide vanes rectifies the flow in the nozzle, so that a good jet may be formed and also guides the spear. As the discharge remains practically constant, and there are no changes of load on the generator, a governor is not required. An overspeed trip to guard against runaway in an emergency is, however, provided. The pendulum, which resembles the one used for the same purpose with steam turbines, takes the form of an unbalanced ring mounted directly on the shaft and held concentric with it by a spring. When the speed of the unit exceeds a given value, the spring pressure is overcome by the increased centrifugal force on the ring and the latter swings over, becoming eccentric with the shaft. In this position it operates the trigger of a trip valve, which admits pressure water to the stainless-steel power cylinder of a deflector, and the deflector is then pushed into the jet so that its energy is diverted from the wheel. (*The Engineer*, vol. 157, no. 4076, Feb. 23, 1934, p. 200, *d*. Compare *Engineering*, vol. 137, no. 3554, Feb. 23, 1934, p. 217)

INTERNAL-COMBUSTION ENGINEERING

Wellworthy Piston and Piston Rings

THE peculiarity of the piston is said to lie in the fact that the bosses for the gudgeon pin are cast integral with struts that reach from the crown to the bottom of the skirt and are separated entirely from the skirt where they emerge at the sides. The resultant distortion of the piston is reduced to a minimum and oil cooling can be effective. This piston was shown at the British Industries Fair at Birmingham where also two of the types of piston rings manufactured by the same company were exhibited. One is of the oil-scraper type and has an unusually wide groove which is said to be less likely to become choked than the usual type. The oil scraped off the cylinder walls is led back into the crankcase through slots in the ring. The makers recommend a vertical clearance for these rings of from 0.003 to 0.004 in. and a back clearance of from 0.01 to 0.015. The other ring is intended for use in cylinders that have become worn and it is claimed to act in a satisfactory manner if

the bore is worn as much as 0.02 in. oval. It is slotted in such a manner that it springs and presses against the top and bottom faces of the groove in the piston while separate springs expand it against the cylinder walls. (Supplement to *The Engineer*, vol. 157, no. 4075, Feb. 16, 1934, p. iv, 2 figs., *d*)

LUBRICATION

Oiliness

THE author states that it is well known that conditions leading to a reduction of film thickness to molecular dimensions, i.e., friction and wear, are dependent on "oiliness." The nature of the lubricating value described by this term is claimed to have become apparent as a result of recent investigations.

Hardy, for example, shows that the partial removal of the active (polar) molecules which adhere to surfaces decreases the lubricating value, but if the residual oil is allowed to stand for a few days at room temperature, it recovers some of its lubricating value in contact with air but not in contact with nitrogen. It appears, therefore, that oiliness or lubricating value depends on the presence in the oil of molecules able to attach themselves firmly to a surface, or on the formation of such molecules as active products of oxidation. From this the author deduces that constituents of a blend should be selected on the basis of oxidation characteristics, and describes experiments made with blends and single varieties.

The considerations mentioned lead to the conclusion that the oxidation-lubrication value of a blended oil especially is dependent on its history as well as on the nature of the constituents. This oxidation activity can be induced readily in a fresh oil containing unsaturated compounds, and in suitable conditions the process will continue by autoxidation, the oil improving in oxidation-lubrication value although not used, an effect which has been observed but not made the subject of special experiments. When, on the other hand, an oil has been used in severe conditions for a period so long that the more easily affected constituents have passed through the early stages of oxidation, greater oxidation stimulation would be required to improve lubricating value, and the effect would diminish on the withdrawal of activation. M.B. oil (a proprietary blend), for example, failed to retain, on standing, the exceptional oxidation-lubrication value stimulated during the course of a long trial. (Paper read by R. O. King before the Institution of Petroleum Technologists, Jan. 9, 1934, abstracted through preprint, 18 pp., 5 figs., *eA*)

MACHINE PARTS (See Internal-Combustion Engineering: Wellworthy Piston and Piston Rings)

MACHINE-SHOP PRACTISE

Steels for Industrial Gearing

IN INDUSTRIAL gearing the majority of failures are said to be due to some form of failure of the surfaces of the teeth that carry the loads. The hardness penetration from surface to core is an important factor which is often neglected. The actual strength of the teeth is not that indicated by the hardness of the steel at the surface but should be calculated from the strength of the steel at the base of the tooth where the stress is greatest. This is illustrated by the author by a table giving the hardness at different depths from the surface for the same gear made of three different materials treated to the correct hardness. In each case the strength at the root is much less than at the surface of the gear.

In general, great care must be employed in using the conventional physical-property values in calculations for the strength of gear teeth. Such values are usually obtained from a 1-in. test bar and may be entirely different from those of a gear tooth, even though made from the same material and given the same heat treatment. The pitch of the teeth and the size and shape of the gear affect these values appreciably. The author says that he has seen cases where steels of apparently suitable characteristics failed through undue wear and yet other steels having the same and sometimes apparently less desirable physical properties were successful when substituted for the original steels.

Beneficial results from a wear standpoint are obtained by making the pinion harder than the gear. In applications where the gear ratio is high and there are no severe shock loads, a case-hardened pinion running with an oil-treated gear treated to a Brinell hardness at which the teeth may be cut after treating is an excellent combination.

The author discusses the proper uses for plain carbon and alloy steels, dividing both into four types, namely, case-hardening steels, full-hardening steels, steels that are heat-treated and drawn to a hardness that permits machining, and steels that are not hardened or treated. The author lists certain steels in his tables as recommended for certain specific purposes. (T. R. Rideout, Nuttall Works, Westinghouse Electric & Mfg. Co. in *Machinery* (New York), vol. 40, no. 5, January, 1934, pp. 268–271, illustrated, *pc*)

MACHINE TOOLS

A Pre-Selective Headstock

THE advent of new cutting alloys has made the matter of reducing idle time on a machine tool of practical importance. It is said that the possibilities in the direction of doing it by the improvement of the single pulley, all-geared headstock were almost exhausted some time ago. Air-operated chucks and electrical controls help in reducing idle time, but not enough. It is claimed, however, that this is done to a very considerable extent by the new head brought out by Alfred Herbert, Ltd., of Coventry, England, to make use of the principle of pre-selection.

The headstock contains a driving shaft, three intermediate shafts, and the main spindle. On the driving shaft is mounted a multiple-disk clutch operated by a hand lever on the top of the headstock for starting and stopping the lathe. This clutch has a patented adjustment which is positive and easily accomplished. When the clutch is released a brake is applied to stop the spindle. Each of the first two intermediate shafts has a double multiple-disk clutch of the same type as that on the driving shaft. The clutch members on these shafts carry driving and driven gears near the ends of the shafts close to the bearings. The third intermediate shaft has a double multiple-disk clutch, which is self-adjusting and spring-loaded to a definite slipping point, so that it safeguards the gears in the headstock from overload and shock in the event of one of the other clutches being overadjusted. Below the intermediate shafts there are three rods parallel with the shafts. These rods are supported in the holes in the headstock in which they can slide. Each rod carries a glut that operates the slider of one of the friction clutches on the three shafts. Lugs on the lower ends of the gluts are engaged by projections on the rims of the two selector disks mounted on a shaft carried in bearings below the sliding rods to which the gluts are fixed. The

selector disks can be turned through gearing by a small pilot wheel on the front end of the headstock. This pilot-wheel shaft carries a dial having the eight spindle speeds marked in large figures on its circumference. By turning the dial until any required speed comes opposite a pointer, the selector disks are set in the position which will allow the projections on their rims to move the gluts and engage those friction clutches which give the spindle speed corresponding with the figure on the dial. A spring plunger that engages a wheel with eight notches on the selector disk shaft insures that the disks remain in the position in which they are set. The selector disks are moved on their respective shafts to engage the friction clutches by a powerful lever at the front of the headstock, which acts through a cam and pair of bell cranks.

When the clutch lever is released, a spring returns the selector disks to the original position. If the clutch lever is not moved, the selector disks may be turned freely into any position by the pilot wheel without producing any effect on the spindle speed.

Thus the dial can be set for the next spindle speed required while the previous operation is still in progress. Subsequently, a pull on the clutch lever instantly brings the new spindle speed into use. Reverse to the spindle is obtained by operating the small lever on the left of the main speed-changing lever. When this small lever is moved to the right, two of the speeds, marked on the dial with a star, become reverse speeds. (*The Engineer*, vol. 157, no. 4074, Feb. 9, 1934, p. 158, 2 figs., *d*)

MARINE ENGINEERING

Motive Power for Cargo Ships

THE first question to be decided is whether a ship should be steam driven or Diesel driven. The author claims that the cost of the Diesel installation is considerably greater than any of the steam units available, and that if serious trouble is to be avoided, the power developed in a Diesel engine at sea and under service conditions should differ from the trial-trip power by about 20 per cent.

As regards steam the following statement has been made: It has been said that the triple-expansion engine will always get home, and that in itself is worth many points in efficiency. For ships up to 9000 tons total deadweight the triple-expansion engine appears to be the most suitable, but so many refinements and improvements have been made in recent years that when he has decided whether a three- or a four-cylinder engine will best suit his vessel, the owner's work has only commenced.

There are on the market today double compound engines, three-cylinder compound engines, cam-driven slide valves, poppet valves, uniflow cylinders, exhaust turbines coupled to the main shaft, exhaust turbines utilized as pressure boosters, combinations of turbo-electric drive and turbo-electric superheaters to regenerate the steam between the cylinders; all of which have their advocates able and willing to prove to the shipowner that their particular apparatus will go a long way to making his fortune. There are tests the shipowner must apply to any of those additions to his engine. The first is the test of simplicity, the second first cost, and the third maintenance. It has been said that in a new ship the saving of one ton of coal a day justifies a capital expenditure of £1000, and W. L. Runciman in his paper stated that this figure was almost certainly too low if the saving is to be enjoyed over the full twenty years' life of the ship; for a vessel steaming at from 9 to 10 knots over 200 days per year, he puts the figure at nearer £2000 per ton of coal saved. The owner who proposes to install a plain triple-expansion engine to give him the required speed at a consumption of 25 tons per day can then afford to spend up to £10,000 on any device or series of devices which will give him a reduction of 20 per cent on his coal consumption, and it would seem that he could get such a reduction for less than Mr. Runciman's equivalent figure of £10,000. (Paper by R. R. Campbell and B. Ramsay, "Some Influences on a Shipowner's Choice of a New Cargo Ship," read February, 1934, before the Institution of Engineers and Shipbuilders in Scotland, abstracted through *The Steam Engineer*, vol. 3, no. 6, March, 1934, pp. 225–227, *c*)

Tests of the Isherwood "Arc" Ship

BRIEF description of the new Isherwood hull was given in MECHANICAL ENGINEERING, Vol. 56, No. 1, January, 1934, pp. 49–50. The loaded trials of the Isherwood Arcform steamer *Arcwear* took place on January 22, 1934, over the Polperro measured mile off the Cornish coast, after which the ship left for Buenos Aires with a cargo of coal. She will return with a grain cargo. On the voyage around from Hull an average speed of 11.15 knots was recorded over a period of 24 hr, with only partial superheat. During the trials eight runs over the measured mile were made, and an average speed of 12.1 knots was recorded, the highest speed being 12.12 knots. This result for a ship designed for a service speed of 11 knots is a very satisfactory one. Sir Joseph Isherwood states that the trial results have exceeded his expectations, and are much better than the tank tests had led him to anticipate. The design of the hull and propelling machinery is such that an increased cargo space of 240 tons has been obtained, compared with a ship of the same 7000 tons dead-weight capacity, while a 20-per cent saving in coal consumption as compared with a normal design of steamer is also promised. On the endurance trial the vessel carried 6850 tons dead-weight on 9085 tons displacement, and attained a speed of 11.15 knots with 1417 ihp at 64.44 rpm and a coal consumption of 20 tons, giving an Admiralty constant of 425—a remarkably good figure—and a coal coefficient of 30,100. (*The Engineer*, vol. 157, no. 4072, Jan. 26, 1934, p. 87, *d*)

Single-Acting Scott Diesel Engine

THIS is a description of a 1250-bhp Scott engine recently installed in the motorship *Yochow*. In December, 1933, an order was placed for a still larger vessel with a higher-powered engine (described in this article) of the same general design as that of the *Yochow*. This is a five-cylinder Diesel motor of the two-stroke, single-acting, port-scavenging type having cylinders 22 in. in diameter with a stroke of 36 in. On test an output of 1660 bhp was maintained at 144 rpm and 1560 bhp at 125 rpm.

The most interesting feature in the engine is the rotary valve in the exhaust pipe from each cylinder. The valve is closed as the piston covers the top of the scavenge ports on its upward stroke, so that none of the scavenge air is lost through the exhaust ports and a slight degree of supercharging is effected. The rotary valve runs at engine speed and it is closed when the lower edge of the piston passes above the lower edge of the exhaust ports. This enables a short piston to be employed, reducing the height of the engine, and, moreover, the space under all the pistons, and in the top frames below, can be utilized for receiving the scavenge air; the usual scavenge trunk, external to the cylinders, is unnecessary. The pistons are, in fact, similar in length to those used in four-stroke single-acting engines.

The spindles of the rotary valves operate in roller bearings

and are not affected by the temperature of the exhaust gas. The drive is transmitted through couplings which allow variations of expansion from cylinder to cylinder. Spiral gears are used at the aft end of the crankshaft to operate these valves, through the intermediary of a vertical shaft in which is incorporated a non-slipping reversing clutch actuated by oil pressure, when the direction of rotation of the engine is reversed.

A somewhat novel scavenging system is employed as described in the original article. The top of the cylinder is of an unusual design, being so shaped that the combustion chamber is almost hemispherical. The fuel, starting, and decompression valves are symmetrically arranged and the top port of the liner is flange-jointed to the lower portion in which are the scavenge ports and water-cooled exhaust ports. In order to transmit the stresses due to combustion, there is a buttress ring and mandrel from which tie bolts pass vertically down to the bedplate cross girders. (*The British Motorship*, vol. 14, no. 167, January, 1934, pp. 376–378, 3 figs., *d*)

Record Reduction in Tonnage, Particularly Steam

DURING the six months ended June 30, 1933, which is the latest date for which particulars are available, the gross reduction in the mercantile marine of the world from all causes was 1,344,321 tons gross. Between 80 and 90 per cent is represented by vessels which have been scrapped, and the figure compares with approximately 1,700,000 tons gross for the whole of 1932. For the complete year 1933 there is no doubt the total reduction will be well over 2,500,000 tons gross, since the rate of scrapping has been accelerated lately, although the possibility that a subsidy will be paid for shipping which is laid up may now cause obsolescent tonnage to be held until the question is settled.

The total tonnage of all ships built in 1933 was probably about 700,000 tons gross. The net reduction of the world's tonnage will therefore prove to be about 2,000,000 tons gross, a figure that has not hitherto been approached in the history of the world's shipbuilding.

This does not represent a large proportion of comparatively modern vessels being broken up, for the average age of the ships which have been scrapped during the past six months is between 25 and 30 years. There is not the least doubt that this scrapping on a wholesale scale will continue, and in conjunction with this is the large amount of obsolete tonnage afloat which is far in excess of the tonnage of vessels now laid up.

Within the course of another year, when perhaps a further 2,500,000 tons gross will have been broken up, the shipbuilding position will become consolidated, and there is therefore scarcely any question that the shipbuilding industry will enter into a period of activity which may develop into prosperity should the present improvement in British and world trade continue.

As a summary of the relative values of steam and motor vessels, it would be difficult to express the matter more succinctly than is done in a statement extracted from the United Molasses Co.'s report published in December, 1933, and expressing the faith in the superiority of the motor vessel. As the ships of the owners trade all over the world—to South Africa, America, India, China, the West Indies, and the Philippine Islands—the advantage of the Diesel-engined ship is not due to any specific cause which would not be of general application.

Evidence such as this, combined with the fact that the Anglo-Saxon Co., owning one of the largest motor fleets in the world, recently ordered 12 oil-engined tankers, makes it quite certain that practically all the oil-carrying ships built in the future will be propelled by internal-combustion machinery. As in normal years the tanker tonnage required will be some 30 to 40 per cent of the total shipbuilding output of the world, the exclusive adoption of the oil engine must be noted by all shipbuilders, marine engineers, and builders of accessory plant. (*The British Motorship*, vol. 14, no. 167, January, 1934, p. 337, *g*)

Calculation of Torsional Vibration Stresses of Marine Oil-Engine Installations

THIS is a mathematical article, not suitable for abstracting, dealing with resonant torsional vibrations, particularly those occurring at critical speeds corresponding to the two-node mode of torsional vibration as well as at critical speeds corresponding to the one-node mode of vibration. The author believes that for the one-node mode of vibration where the relative amplitude at the propeller is large, the probable amplitude of vibration at resonant speeds may be calculated on the assumption that propeller damping is the principal damping influence. For the two-node vibrations, however, the relative amplitude at the propeller is small, so that engine damping must be taken as the basis for calculating the probable vibration amplitudes at resonant speeds. The author's experience in determining engine damping factors is based on measurements made on many different installations.

The author analyzes the principal engine damping forces and gives the methods by which approximate solutions for evaluating engine damping factors may be obtained. He considers the cases of the solid and of the hollow shaft and derives values for the maximum stresses and dynamic magnifiers for certain given materials. Corresponding expressions are given for thin tubes. The author finds that there is a very sudden increase in hysteresis damping when the applied stress range exceeds the critical range for material not previously subjected to cycles of stress above the critical range. He shows the appreciably better vibration-absorbing capacity of material which has previously been subjected to cycles of stress above the critical range, and the somewhat greater damping capacity of thin tubes for the same values of the "equilibrium stress." (The meaning of this term is fully set forth in the original article.)

Since the critical-stress range is in the neighborhood of the endurance limit for alternating torsional stress, attention may be confined for practical purposes to the values of the maximum vibration stresses and dynamic magnifiers corresponding to material which has not been stressed above the critical range. The author has deduced expressions for these quantities from the hysteresis damping constants and exponents given in the paper by Doctor Dorey, "Elastic Hysteresis in the Crankshaft Steels," presented to the Institution of Mechanical Engineers in November, 1932. Here, among other things, he finds that mild steel has appreciably superior vibration-absorbing capacity than the higher tensile steels. For practical applications a simplified formula expressing maximum vibration stress is given. From this formula it would appear that the dynamic magnifier at resonance is inversely proportional to the maximum vibration stress, i.e., to the vibration amplitude, a rate of energy dissipation comparable with that of a marine propeller. Hysteresis damping may therefore be regarded as a powerful means of checking the growth of vibration amplitudes, while the appreciable increase in the vibration-absorbing capacity of material which has previously been subjected to cycles of stress above the critical range may account in part for the diminution of vibration amplitudes sometimes observed after the in-

stallation has been put into service. Fig. 4 in the original article shows observed and calculated dynamic magnifiers for engine damping of two-node vibrations of marine oil-engine installations plotted on a basis of equilibrium amplitudes.

The author considers next the possibility referred to in previous publications that measured amplitudes may be smaller than the possible maximum amplitudes and expresses the belief that cyclic irregularity may account for part of the difference between the calculated and measured amplitudes shown in Fig. 4 already referred to.

He next proposes an alternative method for calculating the amplitude of torsional vibration at resonant speeds, using J, which is the moment of inertia of the oscillating mass of one working cylinder. He then considers as an example a six-cylinder four-stroke-cycle single-acting marine oil engine, 620 mm (24.40 in.) bore by 1300 mm (51.18 in.) stroke tested by the Marine Oil Engine Trials Committee (6th Report of the Transactions of the Institution of Mechanical Engineers, 1931). (W. Kerr Wilson, *Engineering*, vol. 137, no. 3553, Feb. 16, 1934, pp. 167–170, 5 figs., *meA*)

MOTOR-CAR ENGINEERING

Tractors in Soviet Russia

THE data in Table 1 on the number of tractors in Soviet Russia were given by Joseph Stalin in a report, Jan. 26, 1934.

The following remarks are quoted verbatim as to the matter of maintenance of these tractors: It would seem that the presence of such a huge quantity of tractors and machinery would compel the land organs to see that these machines were kept in order, repaired on time, and utilized in a more or less efficient manner. What has been done in this field? Unfortunately, very little. The care of tractors and agricultural machinery is not satisfactory. Repair work is also unsatisfactory, because they still do not wish to understand that the basis of repair work is current repairs and medium repairs and not capital repairs. (*Soviet Union Review*, vol. 12, nos. 2–3, February-March, 1934, pp. 26–29, illustrated, *g*)

TABLE 1 TRACTORS IN AGRICULTURE, U.S.S.R., INCLUDING AMORTIZATION

	Number (in thousands)					Horsepower (in thousands)				
	1929	1930	1931	1932	1933	1929	1930	1931	1932	1933
Total	34.9	72.1	125.3	148.5	204.1	391.4	1003.5	1850	2225	3100
In machine and tractor stations	2.4	31.1	63.3	74.8	122.3	23.9	372.5	848	1077	1782
Tractors on all state farms	9.7	27.7	51.5	64.0	81.8	123.4	483.1	892	1043	1318

New Method of Body Forming

IT IS stated that some Detroit body plants have, for 1935, indicated that automobile shells will be stamped in two pieces instead of the present five or six panels per side, each requiring a separate sheet. Quite recently engineers of one of the leading automobile body plants at Detroit proceeded so far with this idea as to issue trial sheet specifications and orders. To conform to this idea the sheets ordered are in 84-in. widths, 170 in. long, which raises a number of problems for the sheet mill, particularly as on a No. 20 gage sheet 0.0368 in. in thickness, the mill is allowed a tolerance of only 0.005 in.

Like the two halves of an oyster shell, the models for 1935 will be stamped and assembled in the following way: One full-length right stamping, and one-full length left stamping will be welded across the center of the hood, over the middle of the top, and down the back. Only two dies will be used—one for the right and the other for the left side. Each die will start with the front fender, and take in the side panels, quarter panels, and rear fender. (*Steel*, vol. 94, no. 10, Mar. 5, 1934, p. 18, *d*)

Pope Front-Drive Car

THIS is a French car built to the designs of an American engineer, L. A. Pope, formerly builder of the Midland-Pope cars. The present car has a 900-cc (54.9 cu in.) engine with four cylinders in staggered V-formation. The cylinders are set at a sharp angle of 28 deg and the block is extremely short, 11 in. in overall length, an important feature in a front-drive transmission layout. The short two-bearing crankshaft is of exceptional diameter and plain bearings are used both for crankshaft and big ends. The transmission is by bevel gears through a differential to the universal-joint shafts, and it is claimed that the universal joints are well protected. Independent wheel suspension is provided in front by a transverse spring and articulated connecting arms, while at the rear, reversed quarter-elliptic springs are employed. (*The Motor*, vol. 44, no. 1671, Jan. 2, 1934, p. 1086, *d*)

Leyland Titan With Torque Converter

THIS is a description of road tests of a Titan double-deck bus chassis with a torque converter. In the tests a production chassis was used loaded to the legal limit of 10 tons. The torque converter is of the Lysholm-Smith system. The unit consists of a double-acting clutch (for connecting the engine either to the torque converter or directly to the propeller shaft), a three-stage turbine, a free wheel, and a 1-to-1 reverse gear. The turbine multiplies the torque put into it by, at the most, 4.8 times. The addition of a direct mechanical drive permits the whole hydraulic mechanism to remain at rest all the while the vehicle is cruising along in top-gear conditions, that is, when no reduction ratio is necessary. This can be arranged through the free wheel which therefore gives the economy and refinement of free wheeling while retaining the safety factor, namely, that should the engine stop, it can be instantly restarted by engaging the direct-drive clutch. The reverse gear is driven only through the converter and the torque multiplier is equally available when moving backward.

It is claimed that any roughness in the running of the engine is cushioned out because the power is transmitted hydraulically. This is said to be an important point in connection with the use of oil engines, which, in some cases, do not give as smooth torque at low speeds as modern gasoline engines.

The hydraulic drive also damps any propeller-shaft vibration. It is claimed that all of these factors help the efficiency and smoothness of operation of city buses. This is confirmed by acceleration and braking curves in the original article.

The author of the article who made the test (staff member of *The Commerical Motor*) found that the torque-converter drive gives a speed up to about 23 mph, but a convenient speed at which to engage direct drive is about 20 mph.

By pushing the control lever forward one can free-wheel on a down grade or when approaching a stop. The torque converter is engaged for climbing hills and the engine speed is

maintained while the road speed is reduced. On the steepest section of one of the hills the driver could, by easing the throttle, allow the vehicle to come to rest or even to roll backward, no brake application being necessary to hold it, and could at any time draw forward by depressing the accelerator. Having no gears to change and no clutch pedal to use the driver can concentrate on traffic problems with corresponding increase in safety. Other tests, quite strenuous in character, are described in the original article. (*The Commercial Motor*, vol. 58, no. 1505, January, 1934, pp. 832–835, illustrated, *d*)

POWER-PLANT ENGINEERING

Cone-Type Furnace for Burning Powdered Coal

IN THIS type of furnace the combustion chamber has the shape of a truncated cone diverging toward the top. The ascending uniform flow of combustion air passes through this cone. A grain of fuel introduced into this chamber remains there in a state of aerodynamically stable suspension as the

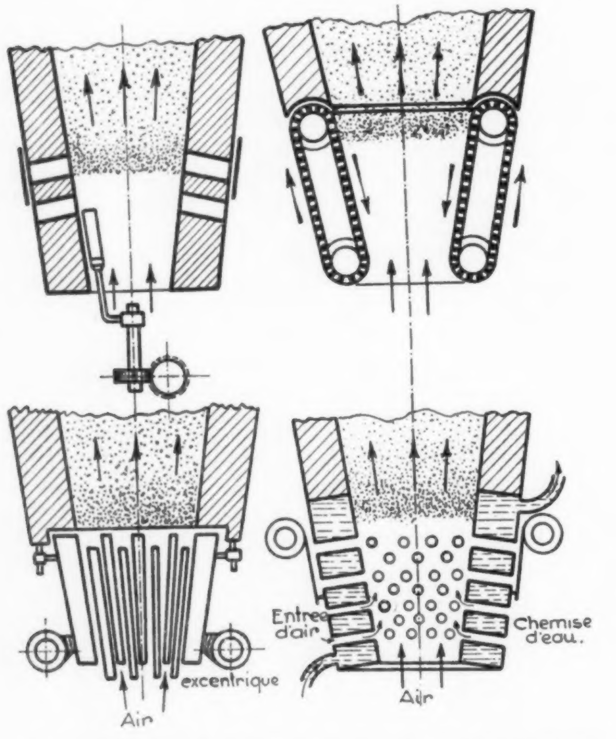


FIG. 1 DIAGRAMMATIC SECTIONS OF THE STOUFF FURNACE CONE
(*Entrée d'air* = air entrance; *chemise d'eau* = water jacket; *excentrique* = eccentric to adjust cone.)

lift produced by the ascending gas tends to counterbalance the weight of the grain, which finally finds its average equilibrium level depending on its characteristics—weight, density, and shape. Moreover, the grain is endowed with an intensive oscillatory movement produced by auxiliary causes, such as lack of uniformity in its shape.

If we introduce into this chamber a large number of grains, they will all pass into a state of indefinite aerodynamically stable suspension. They all possess an oscillatory movement and distribute themselves uniformly. If this "fog" of coal is brought to incandescence, continuous combustion will be obtained by introducing combustible in a predetermined relation to the amount of air flowing.

The length of time that the combustible matter remains in the chamber will be equal to the length of time necessary for its combustion, and the weight or number of grains that can be maintained simultaneously in suspension will be determined automatically.

Certain questions arose when the apparatus was being designed, the first being whether the air necessary for combustion would be sufficient to support the combustible grains in suspension. It was found that the amount of "lifting" air required to support the fuel in suspension decreases with the

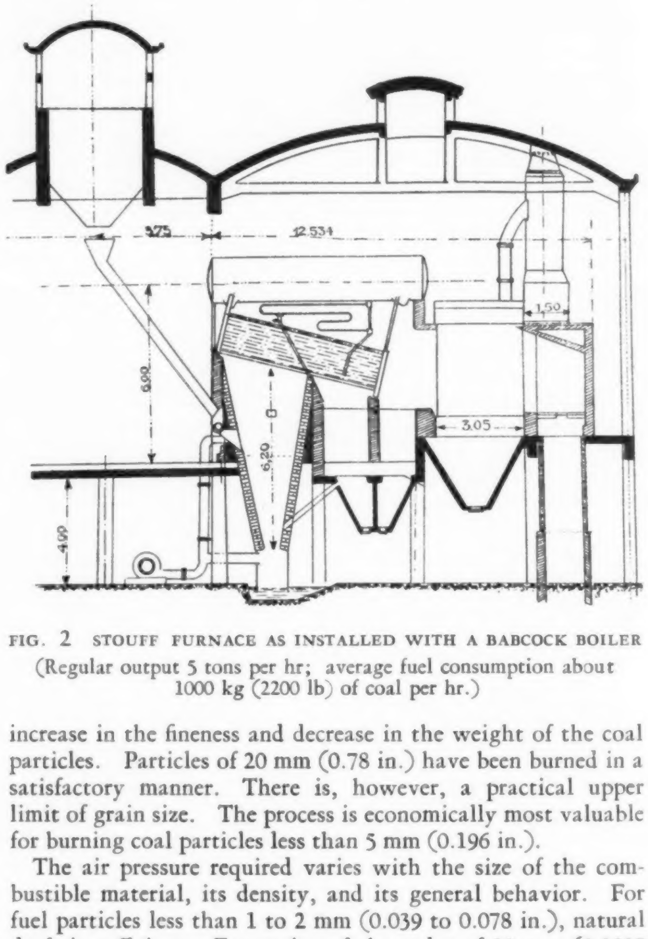


FIG. 2 STOUFF FURNACE AS INSTALLED WITH A BABCOCK BOILER
(Regular output 5 tons per hr; average fuel consumption about 1000 kg (2200 lb) of coal per hr.)

increase in the fineness and decrease in the weight of the coal particles. Particles of 20 mm (0.78 in.) have been burned in a satisfactory manner. There is, however, a practical upper limit of grain size. The process is economically most valuable for burning coal particles less than 5 mm (0.196 in.).

The air pressure required varies with the size of the combustible material, its density, and its general behavior. For fuel particles less than 1 to 2 mm (0.039 to 0.078 in.), natural draft is sufficient. For grains of the order of 10 mm (0.3937 in.) a blower pressure of the order of 50 mm (1.96 in.) of water is sufficient.

In order to provide the best conditions for the removal of ash, it is necessary to keep the fire as low as possible in the cone. The author, therefore, considers the cone as consisting of two horizontal sections, which he describes as follows: The "material" section, the cross-section of which may be reduced to whatever is necessary to get rid of ashes and cinders—and the "air" section, which determines the point below which air has to be blown in. This means simply that part of the air is blown through the wall of the "material" cone itself at a height that can be regulated. The author discusses how this independent regulation of the two sections can be obtained.

The author claims easy ignition and high uniformity of combustion for his apparatus. As to the former, all that is necessary is to create ignitible "fog" by burning some crude oil or kindling in the furnace. The coal is then introduced and catches fire at once.

The shape of the furnace is such as to favor the use of tubular

walls and, it is claimed, insures a combustion with a high percentage of CO_2 and smokeless. This behavior is attributed to what the author calls the remarkable uniformity in the distribution of the grains of fuel, each in some horizontal section of the furnace, as well as the uniformity of rectilinear air-gas streams of equal velocity and free from eddies. This uniformity is established naturally and is due to the uniformity of gaseous currents referred to the intense agitation of the grains as well as possible phenomena of an aerodynamic character due to which the grains repel each other. The other factor affecting performance is the extremely intense renewal of air at the surface of the grains, due to its relative flow, and the oscillatory and gyratory actions of the grains. The duration of combustion is very much less than in any other forms of combustion, according to the author's statement. Finally, there is an intensive radiation from grain to grain, each being completely enveloped in an incandescent mantle of other grains. This gives the most efficient "roof" effect, which again favors the use of tubular walls. Because of the oscillatory movements, there is an actual material transfer of heat from point to point. The author claims that the uniformity of the temperature is remarkable, so that the flame gives the appearance of a uniformly luminous sheet, it being difficult to distinguish the grains from each other or from the wall of the furnace. It is this uniformity of performance which is one of the characteristics that makes it possible to hold in suspension a large number of grains per unit of volume of the combustion chamber. A high velocity of operation is claimed for the process.

The author considers the theory of the process of which only the following will be mentioned:

The lifting force of the air is given by the least-square law for grains of several millimeters and by the Stokes law for grains of less than 1 mm. The temperature of the gas increases with the height in the furnace. It is usually from 0 to 150 C (32 to 302 F) at the bottom, and from 1200 to 1500 C (2192 to 2732 F) in the upper part where the real combustion takes place. Because of this the volume of the gas increases from three to five times in the course of its rise in the furnace. On the other hand, however, the viscosity of gases, unlike that of liquids, increases with the temperature. This has been investigated by Sutherland and from his law it would appear that for the temperature rise in the furnace the viscosity of the gases increases in the ratio of from 1 to 2 to 1 to 3. From this it would appear that for the same dimensions of the section of the furnace, the gas has greater supporting power in the upper part than in the lower part, which is contrary to what is wanted in this case. To meet this condition a large ratio of the extreme sections of the truncated cone had to be adopted, the minimum practical limit being from 10 to 15. The author refers also to studies of the oscillatory motion of the grains, particularly the frequency and amplitude of the oscillations as functions of the density and of the volume of the grains.

From an economic point of view the advantages of the present invention are claimed to be simplicity and low cost of construction, combined with absence of visible smoke and small size of the combustion chamber, as well as the ability to burn coal fines or breeze, including such materials as coke breeze.

Tests were made at the d'Evergincourt plant of the Navarre Paper Co. on a Babcock multi-tubular boiler equipped with the Stouff furnace. (Stouff is the inventor of the furnace here described.) The boiler had a heating surface of 250 sq m (2691 sq ft) and a pressure of 15 kg per sq cm (220 lb per sq in.). It was equipped with a superheater having an area of 63 sq m (678 sq ft) and a Green economizer. The tests were carried out with two types of coal: (1) Fines from 0 to 1 mm of Bruay coal containing 2.05 per cent moisture, 24.35 per cent ash, 25.83 per cent volatile matter, and 47.77 per cent carbon; and (2) fines from 0 to 5 mm of la Mure coal containing 4.79 per cent moisture, 20.84 per cent ash, 6.83 per cent volatile matter, and 67.54 per cent carbon. The tests were made with the unit operating at normal load and with a somewhat reduced range of load changes. Tests on flexibility of operation were carried out with the Bruay coal.

In order to understand the results it is necessary to remember the following points: (1) The boiler was not designed for use with this particular furnace and certain parts are not suited for ease of removal of cinders and ashes which therefore can form deposits on the various points in the lower part of the gas stream. (2) The tests were made without having made an adequate preliminary study of the fuel to learn how to handle it. The matter of handling had therefore to be adjusted while the tests were going on, which did not improve the results.

The results obtained are reported in the original article. A distribution of heat with the Bruay bituminous coal was substantially as follows: Efficiency, 78.3 per cent; losses in solid residues, 8.8 per cent; losses in gas residues, 7.8 per cent; radiation and other losses, 5.1 per cent. The distribution of heat was not as favorable in tests with the la Mure anthracite, for which, however, reasonable explanations are available, and the report of the test bureau states that if the tests were carried under better conditions an efficiency not far from 75 per cent would have been obtained.

As regards flexibility, a test was carried out on July 13 with Bruay bituminous coal with the following results: Operation at the rate of 6 tons could be maintained easily under the same conditions as obtained during the evaporative test (4 tons) in so far as losses through the smokestack and in solid ash are concerned. A somewhat different regulation of the air injected at the base of the cone made it possible to obtain operation with molten ashes which were removed without the fireman's aid. Operation at the rate of 2 tons could be maintained easily. It would seem that operation at an even lower rate could have been maintained if the steam pressure in the distribution system had not fallen off excessively. Changes in rates of operation were easily accomplished by means of a simple control of the distribution of coal and air. It was observed that there was only a relatively slight tendency to carry the ashes into the smokestack. When the control of the firing was correct there was not even any gray smoke at the chimney. (The original article is by L. Stouff in *Revue Universelle des Mines de la Métallurgie et des Travaux Publics*, series 8, vol. 10, no. 2, Jan. 15, 1934, pp. 44–48, illustrated. The report is signed by Roger Martin, same publication, pp. 48–50, *dA*)

RAILROAD ENGINEERING

Altek Mechanically Cooled Refrigerator Car

THIS car has been developed by the Altek Company, Antwerp, Belgium, and is said to be the only perishable-goods car ever awarded a certificate of capability by Lloyd's Register of Shipping. An 8- to 10-hp full-Diesel engine is used to operate the refrigerating unit comprising a two-stage ammonia compressor, which is built to maintain for eight days without servicing any desired temperature between 15 and 60 F under external conditions varying from 0 to 110 F. The refrigerating plant is housed in a space 3 ft 6 in. deep extending across one end of the car. The two-stage ammonia compressor is connected to the Diesel engine by a gear transmission. The remainder of the equipment consists of an evaporator in the form of a direct air cooler, an air-cooled condenser, a 3-kw generator driven by V-belts from the Diesel flywheel, an electrically

driven fan which circulates air in the car, and an electric heating apparatus for use when particular cargoes require it. Fuel and water tanks are installed under the roof and a special control gear is provided to govern the automatic operation of the refrigeration unit. The walls are insulated with 2 in. of slab cork and 4 in. of "dry-zero" blanket, the floor with 5 in. of granulated cork, and the roof with 5 in. of "dry-zero" blanket. The details of the construction are given in the original article. (*Railway Mechanical Engineer*, vol. 108, no. 1, January, 1934, pp. 11–13, 4 figs., *d*)

Steam Ejector Systems for Air Conditioning

THUS far, two types of installation for air conditioning have been used on American railroads. One has used ice as a cooling medium, while the other has resorted to mechanical refrigeration. A third solution has now been offered in the steam-ejector refrigeration machine.

Cold water, circulating through the cooling coil of the air-conditioning unit (Fig. 3), receives heat from the air and flows

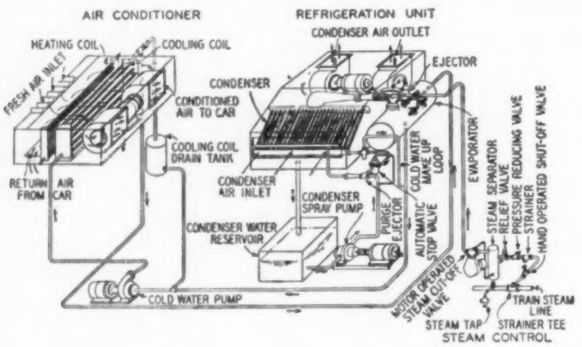


FIG. 3 DIAGRAM OF THE STEAM-EJECTOR CAR-CONDITIONING SYSTEM

thence to a chamber or evaporator into which it is sprayed. This evaporator is maintained at a vacuum so high that it permits the boiling of the water, cold as it is (40 to 50 F). The evaporation of a portion of this water cools the rest, which is then recirculated by a pump to cool the air further.

The steam ejector maintains the vacuum which permits this evaporation. To do this, steam from the train steam line is admitted through a nozzle to the end of the venturi-shaped tube forming the ejector. In expanding from its fixed positive pressure to the high vacuum it attains an enormous velocity, which permits it to entrain vapor from the evaporator. This vapor enters the ejector near the nozzle. It is first accelerated and mixed with the high-velocity steam; then, due to the shape of the venturi, the mixture is compressed, changing its velocity energy to pressure. The compressed mixture is delivered to a special type of air condenser in which it is condensed. It is apparent that the function of the ejector is like that of the mechanical compressor, to draw refrigerant from the evaporator and compress it so that it can be condensed by giving up heat to the outside air.

A part of the condensate thus formed is automatically returned to the evaporator to make up for the evaporation which has occurred. The rest, together with any air leakage into the system, flows into a water-jet ejector which discharges to atmosphere at low pressure through spray nozzles.

The nozzles are so arranged that the spray wets the outside of the finned surface condenser while at the same time air from outside the car is forced over it by means of a fan. The resultant evaporation cools the condenser surface and condenses vapor within the condenser. The air which passes over the condenser is discharged upward and the unevaporated water flows to a reservoir from which it is repumped as needed.

As can be seen, the system consists of a number of more or less closed circuits; the cold-water circuit, the refrigeration circuit, the air-condensate removal circuit, and the condenser-heat removal circuit. These are so interrelated that it is necessary only to supply steam for compression, a small amount of water for condensation, and power for air and water circulation, to obtain refrigeration.

While the main elements of the steam-ejector system have been well known, certain problems had to be solved in the application of this system to railroad-car conditioning. One of these is the design of the condenser. The finned evaporative type of air condenser is old in principle, but by taking advantage of new highly effective forms of surface and by the use of forced circulation, the space occupied and the power required for condensation of the steam are said to have been greatly reduced over conventional types of equipment. An essential part of the design is the use of an all-closed system in which a vacuum is maintained continuously in distinction to earlier types using a jet condenser and a spray air conditioner. By the use of a closed system, it is possible to start refrigeration almost instantly after a short shutdown instead of having to wait until the purge equipment has been able to draw the required vacuum. It is also possible to reduce the size of the purge, as the entrained air which is brought into an open system must no longer be removed. The smaller purge system makes possible combination of functions by the use of a water ejector which acts as both purge and condensate pump and which makes use of the same stream of water with which the condenser surface is flooded. Another elimination of equipment is accomplished in the evaporator feed which returns water from the condenser to the evaporator by balancing the pressure difference with a gravity head, removing the necessity of a valve to control the feed.

It is claimed that the use of the steam-ejector refrigeration system reduces materially the power consumption of the air-conditioning unit and the size of storage battery, as well as the size of the electric generator, the latter from 20.5 kw for a six-ton mechanical refrigeration system to 5.9 kw for a steam ejector system of similar capacity. (C. M. Ashley, Carrier Engineering Corp., Newark, N. J., *Electrical Engineering*, vol. 53, no. 3, March, 1934, pp. 406–410, illustrated, *d*)

Oil-Hydraulic Railcar

THIS car has been recently built by Leyland Motors, Ltd., for the L.M.S. Railway, Great Britain, for service on secondary and branch lines. On service of this kind rapid acceleration plays a vital part in giving a fast service, while the high maximum speed is by itself of comparatively low importance. This feature of operation has been satisfied by the use of cars on two axles.

As regards the hydraulic element the Leyland hydraulic torque converter (for a description, see p. 295) has been used. The power unit is a 130-hp six-cylinder oil engine mounted under the floor and transmits its drive through the hydraulic torque converter to one of the axles. The torque converter and reverse gears are operated by an electropneumatic mechanism, while the throttle, power brake, and hand brake are controlled mechanically.

Full streamlining of the body with its consequent sacrifice in seating accommodations has not been adopted because it was considered that seating capacity on a branch-line service is of greater importance than the possible increase in speed which

might result from streamlining on the rare occasions when high speeds could be desired.

The principal dimensions of the car and other particulars are given in the original article. The engine is of the compression-ignition type, 4.5 in. bore by 6 in. stroke, and develops the rated power of 130 hp at 200 rpm. (*The Engineer*, vol. 157, no. 4076, Feb. 23, 1934, pp. 198–199, illustrated, *d*)

Air Conditioning for Railway Passenger Cars

AIR conditioning is defined here as the simultaneous control of air temperature, humidity, motion, and purity. The temperature inside the railway car should differ from the outside temperature by a variable amount. The ideal way to accomplish this would be by means of a differential thermostat arranged to maintain a zero differential at 72, and a 15-deg differential at 100, with a straight-line characteristic between these points. No instrument of this nature seems to have been developed suitable to meet the rigorous conditions imposed by applications to railway cars. Until it has been developed the best that can be done is to use a thermostat having a variable setting breaking up the range into about four positions, with proper instructions to the porter or brakeman as to the proper setting to select with respect to the outside temperature.

The following four settings are recommended, the first being outside temperature and the second thermostat setting: Up to and including 78 F, 72 F; 79 to 85 F, 76 F; 90 to 94 F, 80 F; 95 F and over, 84 F. These thermostat settings will, with the relative humidity and air motion prevailing within the car, correspond to effective temperatures of 68, 71, 74, and 77 F. In winter a relatively higher temperature must be maintained for comfort.

A true air-conditioning system presupposes some means of heating the air delivered to the car when outside temperatures are such as to require it. Two different methods have been used. In one only a small heating coil is used in the fresh-air inlet. This simply tempers the fresh air so that the mixture of fresh and recirculated air is delivered at the car temperature or slightly above. In the other a larger heating coil is used, which heats the mixture of fresh and recirculated air and delivers it to the car at temperatures considerably above the car temperature.

In the first method, no appreciable heating is accomplished, the air being merely tempered so that no cold drafts will be experienced through the introduction of the outside air. In the second method, considerable heating can be accomplished through the use of the air-conditioning unit alone. The limiting factor is the temperature at which the air can be introduced into the car without causing a hot-blast effect. This seems to be around 100 F, and on this basis the air-conditioning unit alone will supply the heat required down to roughly 20 deg above zero. In colder weather the additional heat required must be furnished by the floor coils.

The author briefly describes the air-conditioning systems now used and additionally points out certain requirements which have to be met in connection with the application of any air-conditioning system to railway equipment, as follows: Safety, reliability, low power consumption, compactness, lightness, simplicity, accessibility, proper air distribution, quietness, low first cost, and low operating cost.

The requisite of safety at once bars the use of any refrigerant, such as ammonia, which would give unpleasant fumes. He therefore recommends freon. He emphasizes the need of low power consumption, because in many cases the locomotive now has only about enough reserve to take care of the usual contingencies and make schedules. The apparatus must be compact. The evaporator is usually placed in a space which cannot be more than 18 in. high or much more than 40 in. wide. The apparatus mounted under the car should not, for general application, be more than 28 in. high or 40 in. wide. The length must be kept at a minimum to avoid extensive rearrangement of existing equipment.

Proper air distribution is most important from the standpoint of the passenger and upon its solution depends the whole success of the installation. The problem is the same regardless of what system is used—ice, mechanical, or steam jet. It is difficult to secure air distribution without causing some draft. The term draft itself is very indefinite and conditions that may be entirely satisfactory to one person will be objected to by another. The average railroad coach will have a net content of from 4500 to 5000 cu ft of air. To secure proper ventilation and cooling it is necessary to supply better than 2000 cu ft of air per min. Manifestly, it is impossible to do this without having some air motion in the car.

Two basic systems have been employed; bulkhead distribution and duct delivery. Many believe that duct delivery is superior to bulkhead with respect to elimination of drafts. Even with the duct system, however, the temperature, velocity, and direction of the delivered air must all be correct if a cold draft down the passengers' necks is to be avoided, and in any case, near the recirculation grille, a very strong and decided draft is felt caused by the recirculated air being sucked up through the grille. In application to existing equipment, duct delivery will increase the cost by from $400 to $800 per car, depending on the construction of the car and type of duct used. On coach equipment this expense can be saved and results secured practically equal to the best duct delivery by placing the conditioning unit in the center of the car and discharging the air in both directions toward the ends of the car. Careful attention is necessary with respect to the velocity of the discharged air. It must be sufficient to carry the air to the ends of the car, but not so high as to cause it to deflect sharply at the end bulkhead. If the velocity is too low, the conditioned air drops at some point before reaching the end of the car. With the proper velocity, however, the air will be carried to the end of the car and gradually diffused with no decided draft. The same problem with respect to the recirculated air is present as with the duct system, but by placing the unit at the center of the car, the amount of air being drawn to the recirculation grille from any section of the car is cut in half, thus automatically cutting down the velocity and so reducing the draft effect.

The author then compares the various systems from the point of view of the factors enumerated.

The ice system is the most reliable. It requires about double the space under the car that would be required for either the mechanical or steam-jet systems and weighs from 3500 to 5500 lb light and between 7000 and 10,000 lb with the full load of ice. Mechanical equipment including the larger generator and battery or mechanical drive weigh from 6000 to 8000 lb per car and the steam-jet system roughly from 7000 to 9000 lb per car. The criticism on reliability of the various types will be found in the original article. With an ice system the total added electrical power load need not amount to more than 25 amp at 30 v and does not require any change in the existing generator or battery equipment. With the mechanical system the power requirements depend on the equivalent refrigeration capacity installed. For a coach this should be from 6 to 7 tons, while a diner or Pullman will require 5 tons. A mechanical system with electric drive will require from 200 to 350 amp at 30 v and this larger power consumption necessitates

the use of a larger generator and battery. To provide sufficient battery capacity to take care of precooling at terminals and to handle the load at intermediate stops a 1000-amp-hr battery is required. As a general rule with the 5-ton equipment a 15-kw generator will be required, and a 20-kw generator with a 7-ton equipment.

With the mechanical system, either electrical or direct drive, the power required presents a real problem. The demand is beyond the capacity of the conventional flat-belt axle generator drive and some form of direct-connected drive or combinations of V-belts is used. Another point to be considered in the power requirements of any mechanical system is the effect on the locomotive. Whether electrical or direct drive is used, the necessary power must ultimately be developed at the rim of the wheel. To develop this power requires an increase in the tractive effort needed to haul the car at any speed. For a 15-car train this may amount to between 10 and 20 per cent of the available tractive effort of the locomotive at speeds of 60 to 70 mph. This means that if the present train and schedule required working the locomotive close to capacity, roughly two cars would have to be taken off the train. Of course to determine this factor exactly for any particular case the characteristics of the air-conditioning equipment, locomotive, train, and schedule must be studied.

With the steam-jet system the added electrical load will be about 75 amp, and while this will usually require some increase in generator and battery capacity, it can be taken care of without any serious trouble. The steam consumption will be around 200 to 250 lb per car which is about what is required for heating in winter. From the locomotive standpoint this system presents no particular problem as the major demand is on the boiler for steam and not on the cylinders for increased tractive power. It does require steam to be furnished to the train at terminals for precooling, and under some conditions this may be a disadvantage.

With regard to costs, several factors must be taken into consideration in order to determine the system with the lowest overall cost for the particular service in mind. The cost of installation will in all cases be the least for the ice system. An ice system can be installed in a coach complete, ready for service, for as low as \$2000, and can run up as high as \$4000.

The cheapest installation of any mechanical system, including larger generator and batteries required, will run around \$6000, and may go up to \$8000 or \$9000. A steam-jet system will cost around \$8000 installed. When it comes to maintenance costs, it is difficult at present to get any reliable figures for comparison. Maintenance costs on mechanical systems so far have been high, running in some cases from \$100 to \$150 per month of operation. These should come down as the equipment is perfected. A fair figure is \$15 per month for ice, and \$25 for the the steam-jet should be ample. The operating cost will be highest with the ice system due to the cost of ice and will vary according to the daily ice consumption which depends on the length of the run and weather conditions. A fair estimate for the cooling season can be arrived at by assuming an ice consumption of 300 lb per hr. This, multiplied by the number of hours in the run and by the number of days in the cooling season, will give a fair approximation of the ice consumption to be expected in this locality. Operating costs for mechanical and steam-jet systems will depend upon the amount of power furnished in yard charging or terminal steam for precooling. (Paper presented before the American Institute of Electrical Engineers, March 20, 1934, by K. Cartwright, Asst. M.E., N. Y., N. H., and H. R.R. Co., abstracted from manuscript, *dc*)

REFRIGERATION (See Railroad Engineering: Altek Mechanically Cooled Refrigerator Car)

SPECIAL MACHINERY (See also Motor-Car Engineering: Leyland Titan With Torque Converter)

Centrifugal Separation of Oily Bilge Water

ONE of the most difficult problems of separation of two liquids is encountered where high-gravity mineral oil must be separated from cold fresh water, owing to the fact that the gravities of the fluids approximate each other very closely and that it is extremely difficult to eliminate the fluorescing film from the water. It is claimed that the "cosmic" centrifuge, built by Centrifugers, Ltd., London, can do this. The principle of this centrifuge is that the rotor is operated at high speed solely by the passage of the fluid through suitable reaction nozzles, and no external mechanical drive is used. Since the rotor is always full it is maintained in a balanced condition, and the upward thrust of the fluid results in a tendency of the rotor to float. This tendency is controlled by a self-aligning double-thrust ball bearing. Within the rotor is a series of vanes so constructed as to lead the fluid through a series of parallel vertical tubes, with the purpose of reducing turbulence to a minimum. Thence the fluid enters a compartmented portion of the rotor formed by a number of radial and tangential vanes. These vanes are so placed that the effective hydraulic mean depth of the axial channels between them is small enough approximately to satisfy, for the liquid to be treated and the rate of flow desired, conditions of laminar flow. The water outlet is located by means of a collecting dome inside the rotor, around the edge of which the water flows toward the reaction nozzles. The oil collects on the underside of the dome, where are situated two floats which maintain a position relative to the dividing line between the oil and water streams, and so control ports that the oil outlet is always the correct size to deal with the oil flow. A revolution indicator is situated on the top of the stator casting, and this shows when the rotor speed is high enough to effect separation.

One interesting feature of this new method of dealing with bilge and ballast water is that it may alter the present procedure on board ship. The pumping of bilge can be done at any time either during the voyage or while in harbor. In the case of the oily ballast tanks, it will be possible to wash these down during the voyage, clean the oily water with the centrifuge, and then fill the tanks with sea water, which can be pumped straight overboard at any time. It is claimed that the same makers are at present considering the production of centrifugal oil purifiers capable of handling the entire flow of lubricating oil in circuits of all prime movers. (*The Marine Engineer*, vol. 56, no. 675, December, 1933, pp. 358–359, 2 figs., *d*)

Electronic Control in Industry

THE author attempts to give reasons why electronic control has not been more widely accepted industrially and points to the factors that may determine the appropriate fields of electronic and magnetic control. The most attractive applications of the former are where small actuating power is available and high speed of response necessary. For the average general-purpose control the conventional magnetic relay has little competition from the electronic relay, provided actuating power of the order of one watt or more is available and the permissible operating time is not less than about $^1/_{20}$ of a sec. Where the actuating power is very much smaller or the operating time considerably less than $^1/_{20}$ sec, the use of elec-

tronic relays is indicated, although magnetic relays are available that operate on much less than one watt and in operating time much less than $^1/_{20}$ of a sec.

This matter of relative speeds is discussed in some detail. In alternating-current applications magnetic relays practically always respond to some sort of average effect of the impressed voltage or current cycles, while electrical relays may respond to occurrences within individual cycles. This is due to mechanical and electrical inertia of the former and its absence in the latter.

As regards power apparatus and industrial control generally, electronic apparatus for passing power currents primarily has to do with interposing tubes between the supply lines and industrial motors. Motor applications justifying power control by tubes seem to be limited either to very small motors, in which case the tube apparatus is relatively small and cheap and voltage drop through tubes involves negligible power loss, or to very large motors using high voltage, where special requirements of speed, flexibility, or other factors justify the complication, as the voltage drop through the tubes is small compared to line voltage. Neither of these cases has wide application in the industrial field.

The important fairly recent developments in this line all seem to relate to the so-called "commutatorless motor," in which the variation in the distribution of currents in motor windings with time is effected by grid-controlled tubes. This seems to involve a type of motor which is distinct from those now commonly used. The electronic apparatus involved is really a part of the motor and not a distinct and fairly flexible element like the ordinary industrial controller. Applications in the transportation field and possibly for large power main drives will possibly be extensive, but it is difficult to see any justification for extensive industrial use.

The author predicts that power-current applications of tubes in industrial control will be rare with certain exceptions, such as resistance wearing.

A great many drives for machine tools, particularly on lathes, use a direct-current motor with its field regulated by a mechanically operated rheostat which is linked up to a lever at the operating position by means of a spline shaft, gearing, sprockets, chains, etc. In this case a great deal of mechanical apparatus could be eliminated with resulting simplification of machine design by controlling the motor field through a pair of gaseous tubes, which would, in turn, be controlled by a little pilot rheostat or reactor mounted at the operating position. It is doubtful if such a substitution is justifiable at present because of the high initial replacement cost of the tubes, but this will not necessarily be the case in the future.

This seems to the author to be the most promising field for tubes in industrial control as far as field regulation is concerned. There already are, and there will be more, special cases such as those requiring coordination of motor speeds with the feeding of materials, but such jobs are entirely special and not particularly numerous.

The practical situation at the present time may be expressed by the statement that electronic apparatus is not being used in industrial control apparatus in any case where some other kind of apparatus can be found to do the job at a comparable first cost. Industrial tubes have so far been expensive and their life has not been particularly long. Regardless of what may be said by its advocates, such apparatus undeniably requires more intelligence and careful handling than the usual control apparatus. Buyers of industrial control apparatus have become accustomed to installing a controller and to being able to dismiss it from mind with the exception of occasional inexpensive replacement of contacts and the like. Introduction of apparatus requiring fairly frequent and expensive replacements of elements is naturally meeting opposition. To a considerable extent more extensive application of electronic control is awaiting lower tube prices, which may not be practicable until sales volume increases. This is believed to be a temporary condition.

The author likes to compare the present situation with regard to tube apparatus with that existing in the pneumatic automobile-tire industry twenty or more years ago. At that time a single automobile tire cost more than a whole set does today and was a rather unsatisfactory device. There was general dissatisfaction, attempts to design substitutes were numerous, and in some cases fairly successful. Electronic apparatus is just about in this stage today with regard to the industrial control field. The author confidently expects that it will pass through the rest of the cycle in years to come, that we shall have far better tubes in the future at a fraction of the present cost, together with that accumulated skill in their use on the part of manufacturers and users which is indispensable. (C. Stansbury, Cutler-Hammer, Inc., Milwaukee, Wis., in *Electrical World*, vol. 103, no. 4, Jan. 27, 1934, pp. 154–158, illustrated, *p*)

SPECIAL PROCESSES (See also Wood Industries: Sugar and Alcohol Production From Wood Waste)

Rapid Drying With Pulsating Circulating Air

ACCORDING to the laws of heat transfer, particularly those developed by E. Schmidt and R. Hilpert, the following equation applies for the determination of the water evaporated in low-temperature drying as expressed in terms of unit surface of evaporation and unit time:

$$w = \kappa(z_w - z_u) \text{ in kg per sq m per hr (1 kg per sq m } = 0.23 \text{ lb per sq ft)}$$

where κ is the factor of evaporation, functionally similar to the coefficient of heat transfer α, while z_w and z_u are concentrations of steam (in kilograms of steam per kilogram of mixture) at the surface of the material to be dried or in the circulating air. From the law of similarity governing the temperature and diffusion field, as developed by E. Schmidt, Hilpert experimentally reestablished the Lewis relationship $\alpha/\kappa = c_pL$, where c_p is the specific heat of the air and L is the coefficient affected by the material handled, and, for example, in the case of evaporation of water in air with free flow is 0.92. From this it would appear that κ may be increased as well as α, which can be done first of all by increasing the velocity of circulation of air. For certain technical reasons this should not, however, exceed 4, or at most, 6 meters (13.12–19.68 ft) per sec. Even then there is a danger of carrying off dyes, chemicals, etc., which are being dried, by the air stream.

The fact that the blower output increases rapidly with the increase in the velocity of air is in itself economically desirable because it shortens the duration of drying.

It is necessary, however, to find out whether an increase in the difference of concentration, such as is produced by a powerful reduction of the saturation of the circulating air z_u, will produce accelerated drying. This can be done by shutting off the adjustable air admission louvres and passing pure air only through the apparatus.

A test with drying cakes of paint at 50 C by this method has shown a reduction in duration as compared with properly adjusted recirculated-air operation of only about 7 per cent, while the power consumption at the blower increased by about 50 per cent and the consumption of heating steam rose

from about 2.2 to over 3.5 kg per kg of water taken out of the material in drying.

The coefficient of evaporation κ developed from tests of surface evaporation cannot be used for calculating processes of drying of lump goods. At the beginning, drying by evaporation takes place at the surface of the then fully wetted material, and this occurs during the time period of "constant velocity of drying" in substantially the same way as predicted by the Lewis relation in the form developed in the Danzig tests. (See reference to E. Schmidt and R. Hilpert, previously cited.) When, however, the drying begins to extend from the surface to the interior of the material, the capillary and adsorptive processes begin to affect the drying of the moisture contained in the inner layers of the material and works in such a manner that the coefficient κ grows constantly smaller. Here in the pore cavities, the velocity of air circulation is zero.

It is practically useless to attempt to calculate the other resistances occurring in each of the layers. It may be mentioned, however, that the surface tensions in the liquid field capillaries, the adhesion of the films of liquid to particles of solid through adsorption and other processes constitute part of these resistances. None of these factors, however, has to be considered in mechanical processes of drying where the material to be dried is in a state of motion, because in all of these processes the material to be dried is in a state of fine subdivision, has a large effective surface, and is rapidly moved through flowing layers of warm air. Mechanical drying, however, requires a very large amount of space and machinery and therefore can be economically used for certain limited purposes only.

Years ago Nusselt called attention to the fact that the process of diffusion fundamentally differs from the process of heat transfer though expressed by an analogous equation, the difference lying in the fact that the material being dried moves crosswise to the flow, while in heat transmission we are dealing with propagation of effects in an oscillatory manner. This led the author to the idea of assisting this crosswise motion down into the deeper layers of material by means of an artificial process of flow.

In the process newly invented by the author of this article the circulating stream of air is subjected to or superimposed on frequent rhythmic oscillations of pressure, which promote a kind of breathing in the pores of the material to be dried and thereby subject a certain additional surface to the drying reaction. In this case the pressure oscillations are such as can be easily handled mechanically, running up to 100 mm of water (3.97 in.) with a frequency of from 30 to 100 per min.

This secondary flow creates an increased exchange of air in the material to be dried and assists in opening the pores blocked by the presence of the liquid. The oscillations also interfere with the formation of thin enamel-like layers which drying produces on the surface of some materials.

The author proceeds to the calculation of the fundamental physical process of creating breathing in the pores and calls attention to the fact that the precision of the figures which he obtains in view of certain assumptions that he had to make should not be overestimated as they give merely an idea of what happens. He states that the oscillations of pressure produce a material increase in the amount of moisture removed only when one may assume the existence in the material to be dried of spherical pores equipped with cylindrical capillaries. The increase in drying effect is very rapid when the ratio of volumes between the spherical moisture-filled pores and the capillaries with which they connect is so great that at free oscillations of pressure the capillaries are thoroughly moistened from the sphere, and yet enough material is left in the sphere to produce a film on the surface, this film being then carried away by the circulating air. The author refers briefly to the constructional features of this process and describes his tests in detail. (Dr. of Engrg. S. Kiesskalt, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 78, no. 7, Feb. 17, 1934, pp. 217–220, *eA*)

WOOD INDUSTRIES (See also Aeronautics: Plywood and the "Flivver" Airplane)

Sugar and Alcohol Production From Wood Waste

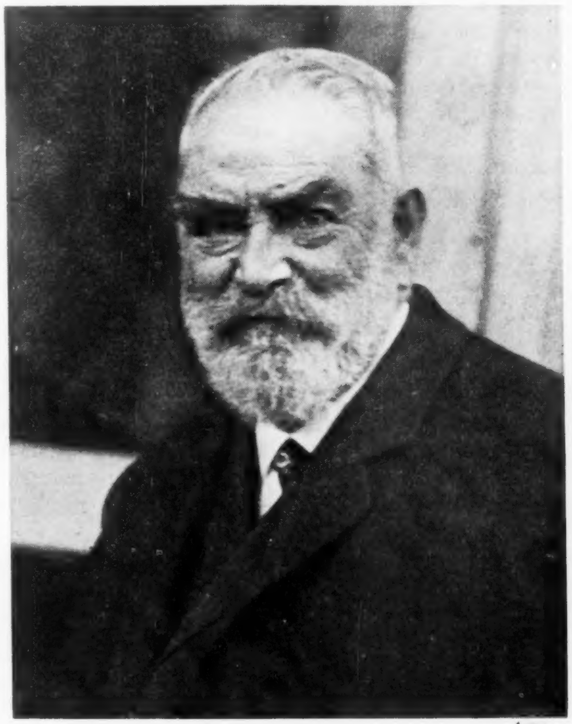
SIXTY-FIVE gallons of ethyl alcohol can be recovered from a ton of wood waste by the Scholler-Tornesch process for sugar conversion. Almost any wood can be used, and with the exception of certain extremely dense varieties, the sugar and alcohol yield are substantially uniform among all common species. The process consists basically of treating wood waste in a percolator with a solution of dilute sulphuric acid forced continuously at 170 C through the wood material. The cellulose is thereby gradually converted into sugar, the acid taking up the sugar formed and removing it from the percolator. Decomposition of the sugar is further prevented by cooling it and by lowering the pressure. The plant for the sugar conversion of wood at Tornesch, near Hamburg, Germany, consists of three cylindrical percolators with a total content of 17,100 gal, capable of handling about 20 tons of wood daily when in full operation. The percolators are made of iron and were at first lined with lead, but are now lined with acid-proof brick. The heat conductivity of this brick is so low that the temperature of the outer iron cylinder does not rise above 60 C, while the interior is between 170 and 180 C (338 to 356 F). The sulphuric acid required is prepared by mixing it with water immediately before it enters the percolator, the mixture containing 0.2 to 0.4 per cent of sulphuric acid. Fresh water is preheated to about 150 C (302 F) in counterflow heaters by means of the sugar wort leaving the percolators, and is then raised to the reaction temperature of from 170 to 180 C by the addition of steam. Thereupon the acid is added to it and the mixture pressed through the cellulose material. The fact that the sugar wort passes through the heat exchangers assists materially in the stabilization of the sugar.

In this process the hydrolyzing liquid does not flow continuously through the cellulose material as was previously the practise, but limited quantities are pressed through at intervals, either by means of their own steam pressure or by the addition of steam. The purpose of it is to gain the same yield of sugar wort at higher concentration. The undecomposed lignin at the bottom of the reaction chamber is broken up and removed by steam and is burned under a steam boiler. There are, however, possibilities of using it for purification of drinking water and water from sewage disposal plants.

The advantage claimed for the Scholler-Tornesch process lies in the fact that the material does not require much preparation and that besides sawdust and wood chips, all other forms of wood waste can be employed. The wood can be either moist or dry and only a single process is necessary to produce from wood cellulose a sugar that can at once be fermented. In addition to alcohol, acetic acid and furfural can be obtained, and the wood-sugar conversion process can be combined with the preparation of tannins. (Article published in *The Timberman*, vol. 35, no. 3, January, 1934, pp. 12–14, and 16, 2 figs., *d*. Based on a paper read by Prof. Luers at the Technical High School, Munich, Germany)

OSKAR VON MILLER, 1855-1934

OSKAR VON MILLER, pioneer in electrical generation and distribution in Germany, founder of the world-famous Deutsches Museum, Munich, and honorary member of The American Society of Mechanical Engineers, died in Munich on April 9, 1934. His long and honorable career was closely identified in Germany with the growth of the electrical industry which has wrought far-reaching changes in industrial and domestic life and in western culture. He labored with vision, intelligence, and energy, keenly conscious of these changes and astute enough to realize the necessity of impressing upon the youth of Germany the significance of the powerful technological influences that determine the environment in which their lives are lived.


Acme

OSKAR VON MILLER

Oskar von Miller was born at Munich, May 7, 1855, the tenth child in a family of fourteen. His grandfather had been director of the Academy of Art in Munich, and his father, Ferdinand von Miller, the head of a bronze foundry, was an artizan of considerable ability and won government awards for his statues. His mother, Anna von Pösl, the daughter of a family of high social and governmental standing, whose marriage with Ferdinand von Miller was contrary to the wishes of her parents, found time, in spite of the large family, to keep the books for the foundry.

The children were strictly brought up and encouraged in self-support at an early age. Oskar von Miller attended the Technische Hochschule at Munich and, after having been graduated from it at the head of his class, entered the civil service, holding several transportation posts during the next few years. Among his early engineering tasks was the building of a bridge over the River Main in the winter of 1879 when the weather was so cold that no one else could be found to do the work.

But von Miller's major engineering interest, that of the electrical industry, began in 1881 when he asked for and received a furlough and journeyed to Paris to see the First Electrical Exposition. Here he became intensely interested in electricity and its applications with the result that he organized an electrical exhibit in Munich in 1882, at which the French engineer, Deprez, successfully transmitted direct current from Miesbach to the Glaspalast in Munich, a distance of 57 km.

Following the successful Munich exhibit, von Miller was sent abroad to France, England, and America to study the technology of the infant electrical industries. It was in this journey that he met Edison for the first time, and, on his return, in Vienna, Emil Rathenau, who was contemplating the introduction of Mr. Edison's electric lighting plants in Germany. Rathenau made von Miller an unexpected and flattering offer to join his venture, but this was refused because of the latter's desire to spend his talents and energy in the service of the Bavarian state. He envisioned the development of the water-power resources of Bavaria, but his superior considered the plans premature. Perhaps it was the spirit of the times, combined with his own enthusiasm and the experiences of his travels that inspired young von Miller in the vision he was to live to see a reality many years later. The young German empire, politically powerful after the crushing defeats of Austria and France, and guided by the forceful Bismark, was emerging from an agricultural into an industrial nation of first rank, rich in resources of materials and human energy, and possessed of the scientific spirit which provides the basis for technological growth. Progress and technological development were in the air.

In Berlin, Emil Rathenau had formed the German Edison Company, now known as the A.E.G., and in 1883 von Miller joined him as a director of the company. By 1884 they had opened the first central station in Berlin. Here the boilers were set above the engine room where Edison bipolar dynamos were driven by belt, three to every engine. For the next five years they were busy developing electrical power plants throughout Germany.

Yielding to his desire to return to his native Munich, von Miller left the A.E.G. in 1889. Life was not easy, but the director of the Portland Cement Works at Lauffen sought him out with a proposition to supply the city of Heilbronn with power from Lauffen. This he accomplished, completing the work just prior to the electrical exposition at Frankfurt, in 1891, of which he became the president.

While power had been transmitted at the Munich exposition, electrical generation was there the major interest. Electrical transmission over considerable distances appealed to von Miller and the idea of transmitting electricity from his Lauffen plant to Frankfurt seemed worth trying. Consultation with Charles E. L. Brown convinced him that an alternating current could be so transmitted, as indeed it was, at 25,000 volts over a three-phase system 178 km in length. Of the 234 horsepower at Lauffen, 181 reached Frankfurt, a loss of only 22.6 per cent. In the same year, at Kassel, von Miller installed the first alternating-direct-current system, in which electricity was transmitted as alternating current and converted to direct current for use.

Following the Frankfurt exhibition, von Miller was firmly established as an electrical engineer and his genius was providing electric lighting and power plants throughout Germany. Space will not permit even a list of these projects. His interests spread to railway electrification and to the use of electricity in the chemical industry and for cooking and domestic appli-

ances. In 1911 there were initiated the plans for the comprehensive hydroelectric power development of Bavaria, totaling 600,000 kva and comprising the famous 168,000-hp project at Walchensee, opened in 1924, with its 1000 km, 100,000-volt transmission system, and a yearly output of 180 million kilowatthours. Thus came to fruition the dream of his young manhood. In 1930, an extensive plan for the electrification of all of Germany engaged his attention.

But important as these engineering achievements of von Miller proved to be, he is best known throughout Germany and the world at large for the Deutsches Museum in Munich. His interest in the museum idea is said to have originated in a visit to Kensington Museum in 1878 when he saw the famous "Puffing Billy," built by William Hedley in 1813, and Stephenson's "Rocket." Lying fallow in his mind for a quarter of a century, the idea of a museum for his native city in which laymen and young people could see the industrial foundations on which our present civilization is based was presented by him to a group of government representatives, fellow citizens, scholars, and technologists in 1903, and he became the founder, president, and director of the institution. To this project he gave the best of his energy and enthusiasm and drove it through to an amazingly popular success in spite of tremendous difficulties.

When it outgrew its original quarters a few years after its opening, the city of Munich provided a commanding site for new buildings on a beautifully located island in the River Isar. Here, in 1925, after the long delay of the War, the present museum was opened to the public. Thousands of visitors to Munich pass through its 400 separate rooms and halls and from a city of 700,000, more than a million pass every year along the nine miles of its exhibits. It has provided inspiration for the founding of similar museums in this country. Space will not permit an estimate of what this great contribution means to the world's understanding of the conditions under which men live and how technology is constantly undergoing development.

Von Miller possessed to a rare degree human qualities that endeared him to every one. His tireless energy permitted him to accomplish great deeds and his infectious enthusiasm carried others along with him in the pursuit of his objectives. Breadth of vision provided these objectives in heroic measure, and a keen sense of his obligation to his country and its culture led him to give his services to such projects of social significance as the electrical exhibitions of his early manhood and the museum and the electrical development of Bavaria which occupied his later years. When the great von Miller saw a need, he did not stop until he had satisfied it, true to his family motto, "If I rest, I rust."

Heat-Transfer Rates in Refrigerating and Air-Cooling Apparatus

(*Continued from page 287*)

Linge recommends the lower calculated curve in each case as giving representative values. A comparison was also made, using Nusselt's formulas, of the condensation coefficients of different refrigerants. The results obtained were that at the common temperature of 70 F, the coefficients for sulphur dioxide and carbon dioxide were 30 and 59 per cent less, respectively, than those for ammonia. It should be remembered, however, that the water, scale, and oil coefficients are likely to be the limiting factors rather than the condensate film, so that under the same conditions, the overall coefficients for these other refrigerants will be only moderately less than for ammonia.

The New Deal and the Engineer

(*Continued from page 262*)

It will be changing the rules indeed if Congress utilizes its power to issue currency on the basis of the revalued gold supply or if the President uses certain powers which he now possesses. These are the things to be feared. Inflationist appetite grows with each feeding. Restoring prices to the 1926 level is unfair, in my judgment, to all creditors except those who became creditors at that or a higher price level. A commodity price level substantially in excess of that of 1926 has been recorded during only about four years of our entire history. Many of us think low prices not so much a cause as a symptom of depression. We recognize that commodity prices affect gold supply, but are unconvinced of a reverse causation. Prosperity raises prices, but you can't force prosperity by increasing prices. We think, on the contrary, that in recent years our price movements have shown a growing independence of gold stocks. We have lived with a dollar of standard weight, with only one regrettable departure, for just a century, and see no need for radical change. Some of us who favored Professor Fisher's plan for a compensated dollar never thought to see it used to force a change of prices of such magnitude that it amounts to a large and sudden redistribution of wealth. As now advocated and applied, the compensated dollar is a capital tax—not a frank and open confiscation, but an indirect transfer of savings from certain groups to certain other groups.

But even now, "things might be worse." Every great depression has been called unprecedented. The other day I read this: "Society has played out its last stroke. It is checkmated. Young men have no hope. Adults stand like day-laborers, idle in the streets. None calleth us to labor. The present generation is bankrupt of principles and hope, as of property." Your Yankee philosopher, Ralph Waldo Emerson, wrote it, not in 1934, but in 1834.

The time will come—I hope I live to see it—when, while we shall shudder to read of the disasters of these four years, we shall yet smile to remember the hopeless pessimism of a few. Our national income last year was pretty low—perhaps 40 billions; but when we last earned this income, in 1913, we thought of it as pretty good. The all-time peak of annual average real wages in manufacturing was attained, not in 1929 ($1385) but in 1931 ($1510). The years 1932 and 1933 were bad years, it is true. But allowing for the fall in prices, commodity buying power in those years was only 13 to 20 per cent below the high level of 1929. There are better things ahead, better than we have ever known. I believe it, so do you. We have been advised not to sell America short. More important still, just now, while we relieve distress and root out what is bad, we should be determined not to tear down except to build better. It is important not to breed any new race of rats. The only revolution we have to fear is a revolution in the minds of men which makes it impossible to do business together.

CORRESPONDENCE

Post-Graduate Education

To the Editor:

I read with a good deal of interest Professor Faires's letter on post-graduation education.[1] While agreeing with him that a man who has taken a B.S. degree in engineering might complete the subjects lacking for the B.A. by correspondence, I am afraid that there will be few, if any, institutions where the faculty of the arts college would vote in favor of it. From a long experience, it has been my observation that such faculties are extremely sensitive and jealous of their particular courses and the requirements for the B.A. degree. To suggest that a student complete his real or residential university work in a college of engineering and then adopt the correspondence-school method for the B.A. degree would be interpreted as a distinct slur.

After having obtained one bachelor's degree, would there be much of an incentive for a man to take another similar degree? Would it not be better to insist that one of the qualifications for the professional degrees (C.E., M.E., E.E., etc.), which are, in many cases, not given without a good deal of post-graduate professional experience and study, should be a directed course of reading in literature and other non-technical studies, and particular insistence that the thesis should be subject to criticism or rejection if it was not written in good English.

I would also venture to suggest that perhaps it might be as well to stop hammering home the idea that the engineer, *ipso facto*, cannot write decent English. In the past it was doubtless true that undue emphasis was placed upon purely technical subjects, but one of the results of the S.P.E.E. investigation was the broadening of the general undergraduate engineering course. The time devoted to the study of English and other courses of a non-technical nature has certainly been increased, so that I feel that the above criticism should not have the same prominence in connection with the coming generation of engineers.

H. C. Sadler.[2]

Ann Arbor, Mich.

To the Editor:

The plan presented by V. M. Faires[1] for post-graduate education through the correspondence-school method has been of considerable interest to me in that it seems to provide an excellent medium for the training of the "social engineer." This relatively new phase of engineering was ably presented by R. E. Flanders in the February issue of Mechanical Engineering. One reason for my belief is that to attain such a "high degree of objectivity" as stressed by Mr. Flanders is extremely difficult in an environment which is not conducive, in general, to that sense of social debt which should be the very foundation of such attainment. Further, it is practically impossible to devote enough time to the required courses when universities are already extending their regular engineering courses to five years in some cases.

Mr. Flanders did not state how much time he would recommend for such training, but it is obvious that one full year could only scratch the surface. Few students could afford to spend much more time in school. On the other hand, if they became self-supporting, they would probably be willing to devote, perhaps three years of home study to a well-planned course. The total expenditure of money should not be over $250, based on the correspondence courses of this length.

It is regrettable that Mr. Flanders did not hazard an outline of study for such a course. However, one realizes the prudence of this apparent omission when he tries to visualize the true objective. The difficulty does not seem to lie in the choice of the subject matter for the courses but in the presentation. In other words it appears that the functional phase of each course is all-important to the social engineer. For this reason the courses presented will perhaps need considerable revision in the matter of lectures accompanying the texts. This seems to point to the fact that a great deal of cooperation between able industrial men and educators is yet required before a suitable course can be formulated.

The question of which universities would be best suited for such work is open to some discussion, but it is my belief that a few correspondence schools already well established are very open to new thoughts and should be very willing to cooperate. The traditional disdain for the correspondence-school methods is soon abolished when once the college graduate has been willing to submit to this form of instruction through a reliable school.

As to the degree for incentive, as mentioned by Professor Faires, I am inclined to feel that if it will encourage the graduate to carry on it will serve its one useful purpose. If, after completion of the course, however, the student still feels that the degree was the important thing, the course will have failed.

Stanley A. Kilpatrick.[3]

Baltimore, Md.

What Are Fair Profits?

To the Editor:

Profits have been defined in many ways, mostly savoring of law and morals, and still an engineering definition is lacking. The writer ventures to define operating profits, either of production or of distribution, as that "factor of safety," over and above cost of possession and maintenance, which assures the continuance and normal growth of the enterprise. This will vary with the character of the business just as mechanical factors of safety vary with the character of the material or structure in question. Speculative profits, which are the accidental difference between the income from and the cost of speculative transactions, cannot be defined at all and are, in the long run, balanced by equal losses in accordance with the general laws of probability. The public is very much confused because these two concepts go by the same name.

The source of operating profits is the combination of elements, such as material, labor, land, time, and place. Profits derived from circumstances of scarcity are speculative. Under conditions of prosperity it is evident that both "labor" and "capital" derive profits, since all wages over the minimum of subsistence the classical definition) are a share of profits, the result of the

[1] See Mechanical Engineering, March, 1934, p. 179.

[2] Dean, College of Engineering, University of Michigan. Mem. A.S.M.E.

[3] Aircraft Stress Analyst, Glenn L. Martin Co. Jun. A.S.M.E.

aforesaid favorable combination of elements. The conclusion seems almost self-evident that profits on labor, raw material, or land pure and simple are speculative and therefore unfair as operating profits, since unnecessary as a factor of safety, and the necessary and fair profits are those on buildings, equipment, and the organization of these with regard to time and place which results in the whole being greater than the parts. For instance, if one could imagine a rampart of earth being constructed by the bare hands of the workers, there could be no profits except those resulting from the skilful direction of the overseer. As soon as tools are introduced and from there on to the use of machinery and power, profits become both available and necessary, and the amount of these bears a relation, not factorial but rather exponential, to the amount of equipment and power used.

WM. F. TURNBULL.[4]

Tuckahoe, N. Y.

X-Ray Determination of Depth of Cold Working

TO THE EDITOR:

Messrs. Thomassen and McCutcheon[5] deserve considerable credit for developing a new method of attack upon the problem of metal cutting. There are, however, several questions which come to mind, the answers to which may have been omitted from lack of space, or, if not known, may open up new lines of attack.

In etching an alloy there is a possibility of selective solution. Were any tests made to see if the composition of the acid-dissolved material is identical with the body of the metal? If not, the depth measurements would be vitiated. Possibly to check the theory a more homogeneous metal could have been chosen. Does the deformation of crystals at the surface cause a strain, producing an elastic deformation in the body of the metal? If this is so and the structure were restored by etching away the surface material, the results would appear too low.

The curves are, in general, linear, but the conditions of cold working require that the curve pass through the 0-0 intercept. It would be of theoretical interest to examine the curve more fully in that region. On the other hand it seems reasonable to suppose that eventually a point will be reached where increased depth of cut will not increase the depth of cold work—where the cut is so large as to amount to an actual tear. Then the curve will be parallel to the abscissa. Since general practise in industry is to use cuts and feeds much larger than shown, extension of the data in this direction may have practical importance.

J. W. ANDREWS.[6]

Kearny, N. J.

TO THE EDITOR:

Having watched with considerable interest the progress of the experiments reported by Messrs. Thomassen and McCutcheon,[5] I am of the opinion that this method of determining the depth of cold working is superior to any other method employed for this purpose reported on to date. I believe that the results obtained do represent clearly the actual conditions. They would, of course, be changed in magnitude if the tool shape were changed or if other values of depth of cut and feed were used.

[4] Mem. A.S.M.E.

[5] See MECHANICAL ENGINEERING, March, 1934, pp. 155–157.

[6] Engineer, Western Electric Company.

Admittedly, these results, when limited to yellow brass and free-cutting brass as reported on, are consistent. An annealing operation to produce large grain size was necessary, however. It would appear to be very much worth while if this X-ray analysis could be applied to materials of smaller and more complex grain size and structure such as those occurring in steels. From a practical point of view, this study is of great importance as applied to the high-chromium steels and high-manganese steels, that is, those which work harden appreciably due to the distortion of the cutting tool.

It is hoped that the authors may continue these tests using, if possible, some of these steels.

O. W. BOSTON.[7]

Ann Arbor, Mich.

TO THE EDITOR:

In connection with the paper by Messrs. Thomassen and McCutcheon,[5] two X-ray diffraction-patterns photographs of cold-worked steel, Figs. 1 and 2, will be interesting as another example of the effect of cold working. The chemical analyses of the alloy steels of the specimens photographed are practically the same. It is intended to use both for the same work. However, the results from the two different heats or batches were quite dissimilar.

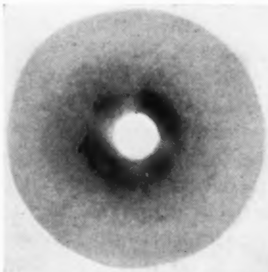


FIG. 1

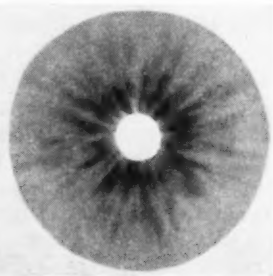


FIG. 2

Pattern photograph Fig. 1, by its directional properties, shows not only the effect of cold working but also that the material was so handled through the hot-rolling and the annealing operations that when the cold-working operation was performed, the effect of the annealing was still in evidence with the effect of the cold working. This gave a satisfactory material. Cutting tools and operations performed made possible the maintenance of production schedules.

An interesting question here might be, "How much further could this piece have been cold worked and still given satisfactory results from every angle?"

Diffraction-pattern photograph Fig. 2 shows an irregular orientation of the crystals. It reveals a bent, distorted, unorganized condition throughout. This condition might have been caused in the hot rolling and by improper annealing and the leaving of too much to be performed in finishing by cold working.

The depth of cold working on these two similar materials of approximately the same analysis and hardness would be very much different. Fig. 1 represents an ideal material, and Fig. 2 an unsatisfactory material that upsets all standard practises. The microscopic examination varied so that nothing definite could be learned from it, and it took X-ray diffraction patterns to show the actual orientation of the crystals in the structure.

In putting the information gained by the authors into general use so the investigations can be carried on with other ma-

[7] College of Engineering, University of Michigan. Mem. A.S.M.E.

terials, the real crux of the matter lies. The real value of research lies in its practical applicability to material problems. As to hardness tests, what Messrs. Thomassen and McCutcheon say is true, yet we cannot throw out hardness tests. We must standardize our analyses and the effect of cold rolling with the heat treatment for future reference.

The taking of pattern photographs requires a great deal of time. This is, of course, the sure means of starting right. If the information gained by the authors' investigation through the diffraction photograph can be tabulated along with hardness testing or any other scientific method so that industry can eventually benefit quickly by it, then we shall have been carried a long step forward.

WILLIAM G. PRAED.[8]

Chicago, Ill.

TO THE EDITOR:

Mr. Andrews suggests that during etching it is possible to have a selective solution which would vitiate the depth measurements. We understand this to mean that undissolved crystals would protrude from the surface, making it rough. We have been aware of this possibility and have done considerable experimentation with various etching reagents at different temperatures. It was found that 30 per cent nitric acid at 25 to 30 C gave a very smooth surface.

In the case of 70–30 brass, consisting wholly of the α solid solution phase, no such large difference in rate of solution exists as might be expected in the case of alloys containing several constituents. Working with the leaded brass, all specimens besides being measured to determine dissolved metal were also weighed, and from the loss of weight the thickness of metal lost was computed. In the 29 separate etchings the computed and measured thicknesses agree within 0.0001 in. in seven cases and in seven others, the difference is $\pm$0.0001 in. The largest disagreement found amounts to 0.0004 in. The computed values are scattered on both sides of the measured values. If any appreciable selective action existed, one would certainly expect the measured depths to be consistently lower than those obtained by weighing.

Deformation of crystals at the surface certainly would produce an elastic strain. This strain will, however, not show up in these pictures. At the February meeting of the A.I.M.E. in New York in 1933 we reported on some experiments on brass under tension where no change in the picture was found below the yield point.

We also feel that it would be desirable to extend the results to smaller depths of cut. We appreciate the suggestion of increasing depths of cut.

It would be very interesting to carry out experiments of this kind with alloy steels as Professor Boston suggests. Unfortunately, it is very difficult to obtain good resolution of the $\alpha_1\alpha_2$ doublet for ordinary steels, and it might be expected that the same would apply for alloy steels. Without this resolution, an accurate determination of depth of distortion would be difficult.

Mr. Praed's two pictures are very interesting as another contribution to the effects of cold work in metals.

On page 157 of the paper[5] the word "feed" in the next to the last line of paragraph (1) under Discussion of Results should read "depth of cut."

L. THOMASSEN.[9]
D. M. MCCUTCHEON.[10]

Ann Arbor, Mich.

[8] Claud S. Gordon Co.
[9] Asst. Prof. of Chemical Engineering, University of Michigan.
[10] University of Michigan.

Thermal Conductivity of Gasoline

TO THE EDITOR:

Three years ago M. Daniloff, then a graduate student at Harvard Engineering School, determined experimentally the thermal conductivities of two gasolines in a manner described elsewhere.[11] It would appear that there is no immediate prospect of finding the thermal conductivities of other liquids, so that it was considered advisable to make a note of the values obtained in case they may be useful to others. See Table 1.

TABLE 1 DATA ON GASOLINES

	Deg F	Sample 1	Sample 2
Specific gravity (rel. to water at 60 F)	40	0.7205	0.7608
	50	0.7164	0.7568
	60	0.7116	0.7520
	70	0.7070	0.7475
	80	0.7022	0.7426
Specific heat (rel. to water at 60 F)	40	0.487	0.473
	50	0.494	0.479
	60	0.500	0.485
	70	0.507	0.493
	80	0.514	0.499
Absolute viscosity, centipoises....	40	0.540	0.616
	50	0.514	0.588
	60	0.494	0.564
	70	0.472	0.540
	80	0.454	0.518
Molecular weight		95	102
Initial boiling point, F		115	93
End-point, F		293	405
Thermal conductivity at 30 C (cgs units)		0.000320	0.000318

Two samples of gasoline were tested. No. 1 was a straight-run gasoline and No. 2 was a cracked gasoline. The molecular weight was determined by finding the depression in the freezing point of chemically pure benzol.

The specific heats given were not actual determinations but were derived from A. G. Wilson's chart.[12]

Outside of thermal conductivities, all values were obtained from B. W. Dudley of the Vacuum Oil Company, which supplied the gasoline.

J. F. D. SMITH.[13]

Cambridge, Mass.

Heat Transmission of Steam Flowing in Vertical Tubes

TO THE EDITOR:

In 1916 Nusselt published in the *Zeitschrift des Vereines deutscher Ingenieure* a series of formulas for the condensation of pure vapors on vertical surfaces and horizontal tubes. His formulas for vapors condensing at rest have repeatedly been checked with steam and organic vapors and the test results show good agreement with the theoretical equations.

Recently, M. Jakob, S. Erk, and H. Eck, of the Physikalisch-Technische Reichsanstalt, Berlin, published[14] tests on steam flowing downward at high velocities in a vertical tube. The purpose of their work was to check Nusselt's formula for this case which reads:

[11] J. F. D. Smith, *Indus. and Engrg. Chem.*, November, 1930.
[12] A. G. Wilson, Jr., *Indus. and Engrg. Chem.*, July, 1927.
[13] Instructor in Mechanical Engineering, Harvard Engineering School.
[14] *Forschung auf dem Gebiete des Ingenieurwesens*, vol. 3, no. 4.

$$h = \frac{3}{2}\left(\frac{c_3 k^2 \rho_v \rho_c r g u^2}{12 \mu H(t_v - t_w)}\right)^{1/3}$$

in which

h = film coefficient, kcal/sq m/hr/C, or Btu/sq ft/hr/F
c_3 = constant = 8.08/10[11] (metric) or 2.46/10[11] (English)
k = thermal conductivity of condensate, kcal/m/hr/C, or Btu/ft/hr/F
ρ_c = density of condensate, kg/cu m, or lb/cu ft
ρ_v = density of vapor, kg/cu m, or lb/cu ft
r = latent heat of vapor, kcal/kg, or Btu/lb
g = gravitational constant = 1.27×10^8 (metric) or 4.18×10^8 (English)
u = linear velocity, m/hr, or ft/hr
μ = viscosity of condensate, kg/hr/m, or lb/hr/ft
H = height of vertical surface, m, or ft
t_v = vapor temperature, C or F
t_w = tube-wall temperature, C or F

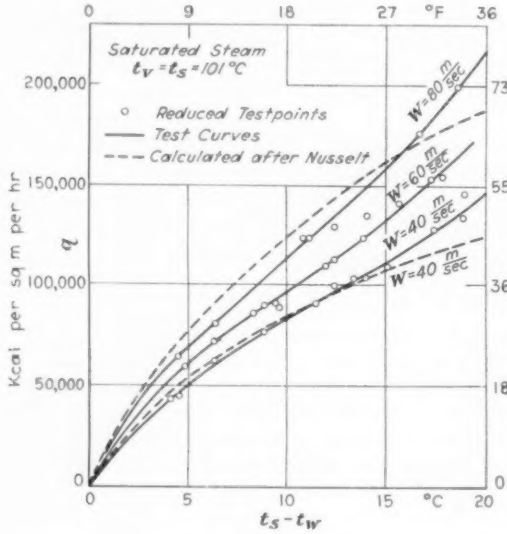


FIG. 1

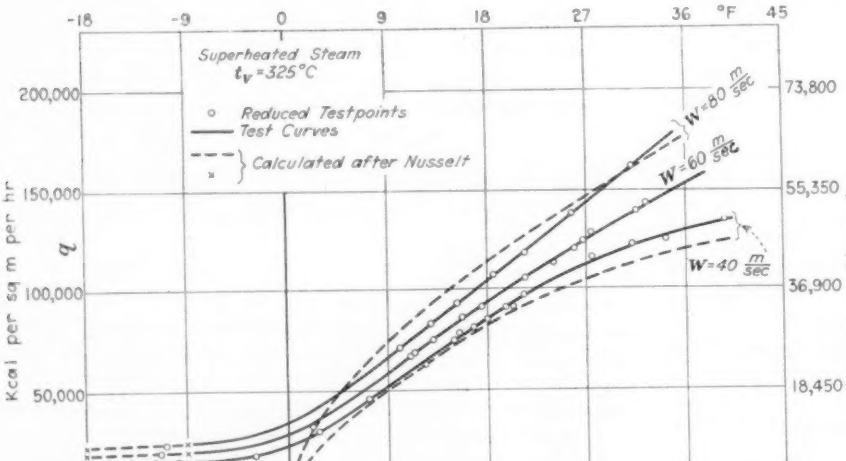


FIG. 2

All terms must be expressed in consistent units, either metric or English.

Jakob and his coworkers conducted their tests with a tube of 40 mm (1.575 in.) inside diameter by 1200 mm (47.2 in.) high. They ran tests for saturated steam of 101 C (213.8 F), corresponding to a pressure of from 1.1 to 1.2 atm abs, as well as for superheated steam of the same pressure and 325 C (617 F). The test results are laid down for saturated steam in Fig. 1 and for superheated steam in Fig. 2. They represent 167 test runs with more than 20,000 readings.

A glance at Figs. 1 and 2 shows test curves for steam velocities w of 80, 60, and 40 m per sec (262, 197, and 131 fps). The original article states that it was practically not possible to run tests only at these velocities, the test data therefore had to be reduced graphically to the above velocities. Nusselt's equation has also been entered into the diagram for velocities of 40 and 80 m per sec. As expected from Nusselt's equation, the transmitted heat depends on the temperature difference between steam and wall and the steam velocity. As a matter of convenience $q = h(t_v - t_w)$, or, in other words, the transmitted heat per square foot per hour for a given temperature difference is plotted against the temperature difference $(t_s - t_w)$, t_s being the saturation temperature of the steam.

In Fig. 1 test curves and theoretical equation show good agreement except for large temperature differences and high velocities where the curves diverge. This indicates that at high velocities steam friction accelerates the condensate in such a manner that no thick film will develop. This is true too for superheated steam as shown in Fig. 2, but less pronounced. The maximum deviation of the test points from the calculated test curves is even less for superheated steam than for saturated steam, except for $t_s = t_w$, where Nusselt's formula does not pretend to hold. The test curves go without any noticeable inconsistency over into the region where the wall temperature lies above the saturation temperature, that means where we have heat transfer without condensation. This seems to be rather surprising. For this region h is calculated after a new formula[15] from Nusselt:

$$h = 0.03955 \left(\frac{g \mu_w}{d}\right)^{1/4} \left(\frac{T_w}{T_0}\right)^{0.417} c_{pw} (w_0 \gamma_w)^{3/4}$$

in which

μ_w = absolute viscosity of the gas at wall temperature, kg hr/m², or lb hr/ft²
d = tube diameter, m, or ft
T_w = absolute temperature of wall, C or F
T_0 = absolute mean temperature of gas in tube cross-section, C or F
c_{pw} = specific heat, kcal/kg/C, or Btu/lb/F
w_0 = mean linear gas velocity, m/hr, or ft/hr
γ_w = density of gas at wall temperature, kg/cu m, or lb/cu ft

Test results and the theoretical formula show excellent agreement for heat transmission without condensation taking place. From these tests it follows that Nusselt's formula holds for saturated as well as superheated steam. For superheated steam instead of the latent heat r, the authors recommend a greater heat content:

$$i_v = c_p(t_v - t_s) + r + c(t_s - t_c)$$

as heat transmission for superheated steam is somewhat better

[15] *Forschung auf dem Gebiete des Ingenieurwesens*, vol. 1, p. 287.

than for saturated steam; in which

i_v = heat content, Btu/lb
c_p = specific heat of vapor at constant pressure, Btu/lb/F
t_v = vapor temperature, F
t_s = saturation temperature of vapor, F
r = latent heat of evaporation, Btu/lb
c = specific heat of condensate, Btu/lb/F
t_c = final temperature of condensate, F.

As the designer uses engineering units, the converted equation is

$$h = 25\left(\frac{k^2 \rho_v \rho_c r v^2}{zH(t_v - t_w)}\right)^{1/3}$$

for condensation at high velocities in vertical tubes, in which v is the linear velocity, in ft per sec, and z the viscosity of condensate in centipoises.

WALTER GLOYER.[16]

New York, N. Y.

A.S.M.E. Boiler Code

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of this Committee in Cases Nos. 763, 767, and 768 as formulated at the meeting of February 16, 1934, they having been approved by the Council. In accordance with established practise, names of inquirers have been omitted.

CASE No. 763

Inquiry: Is it the intent of Pars. P-295 or H-63 and/or H-116 of the Code to permit the introduction of feedwater into a boiler through the water column or its pipe connections?

Reply: It is the opinion of the Committee that Pars. P-295 or H-63 and/or H-116 do not sanction the connection of any device that will permit the introduction of feedwater into a boiler through the water column or its pipe connections (see Pars. H-38 and/or H-91 for the introduction of feedwater into the boiler).

CASE No. 767

(In the hands of the Committee)

CASE No. 768

(In the hands of the Committee)

[16] The M. W. Kellogg Company. Jun. A.S.M.E.

Revisions and Addenda to the Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from any one interested therein. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-9. REVISE SECOND SECTION TO READ:

[The] Pipes [and fittings] used on boilers up to the required valve or valves on ALL [steam] outlets, INCLUDING STEAM LINES, feed lines, blow-off lines and DRAINS shall conform to the specifications for pipes or tubes, OR THEY MAY BE MADE OF FERROUS OR NON-FERROUS MATERIALS HAVING PHYSICAL CHARACTERISTICS WHICH ARE NOT LESS THAN THOSE REQUIRED FOR WELDED AND SEAMLESS STEEL PIPES AND WHOSE STRENGTH IS NOT IMPAIRED BY THE TEMPERATURES TO WHICH THEY MAY BE SUBJECTED (SEE ALSO PAR. P-25).

IN NO CASE SHALL PIPE OR TUBES BE USED OF A THICKNESS LESS THAN "STANDARD" AS GIVEN IN SPECIFICATIONS S-18, S-19, S-23 AND S-24 FOR THE MATERIAL USED.

PAR. P-24. REVISE TO READ:

P-24. *Feedwater Piping.* Feedwater piping SHALL CONFORM TO THE REQUIREMENTS OF PARS. P-9 AND P-300 [may be of welded or seamless pipe of wrought iron, steel, brass, or copper]. The maximum allowable working pressure for feedwater piping and/OR water piping BELOW THE WATER LINE shall be taken as 80 per cent of that for steam piping of the corresponding sizes as given by the rules in Par. P-23.

PAR. P-25. REVISE TO READ:

P-25. *Blow-Off Piping.* THE blow-off piping shall CONFORM TO THE REQUIREMENTS OF PAR. P-9, EXCEPT THAT GALVANIZED [be of black] wrought iron or [black] steel, [not galvanized] BRASS OR COPPER PIPE SHALL NOT BE USED.

THE PIPE [and] shall be AT LEAST AS THICK as [heavy as] required for the feed pipe BY PAR. P-24, EXCEPT THAT FOR PRESSURES OVER 100 LB PER SQ IN., THE THICKNESS SHALL NOT BE [and in no case] less than THAT GIVEN FOR "extra-strong" [pipe size] IN TABLE 2 OF SPECIFICATIONS S-18 AND S-19, AND SHALL ALSO CONFORM TO THE REQUIREMENTS OF PAR. P-300.

PARS. P-105*d* AND U-73*f*:

FLAT HEADS MAY BE WELDED INTO ANY PRESSURE VESSEL UNDER THE RULES GIVEN IN PAR. P-198*a* (U-39*a*), PROVIDED THE WELDING MEETS THE REQUIREMENTS FOR FUSION WELDING FOR THE CLASS OF SERVICE INTENDED, EXCEPT THAT RADIOGRAPH EXAMINATION MAY BE OMITTED. WHEN THE FUSION WELDED VESSEL MUST BE STRESS-RELIEVED, THE FLAT HEAD SHALL ALSO BE STRESS-RELIEVED.

PARS. P-198 AND U-39. REPLACE BY THE FOLLOWING:

P-198 (U-39). *a Flat Heads.* The minimum required thick-

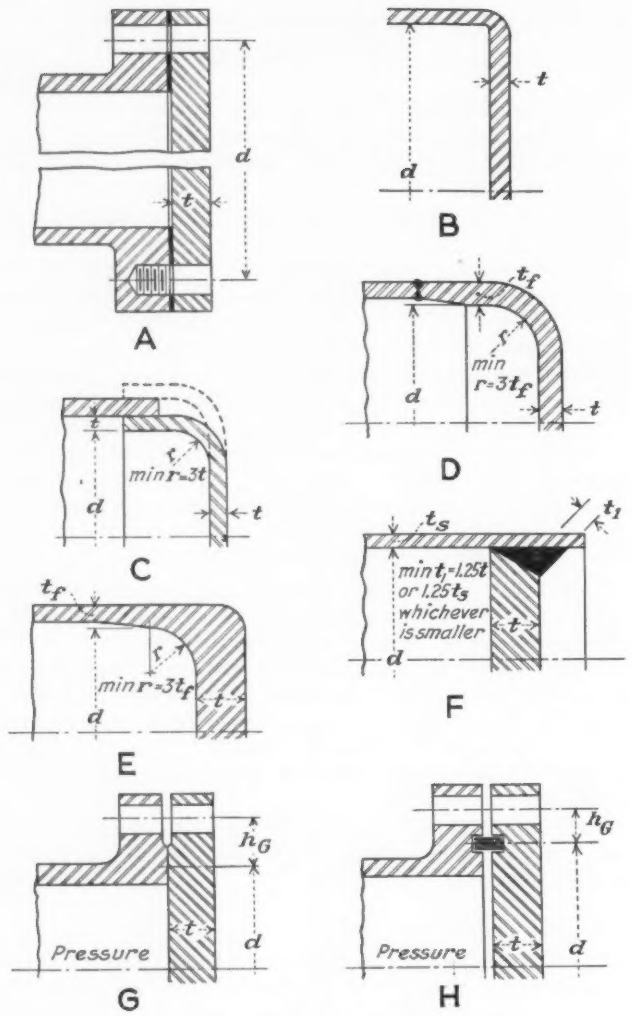


FIG. P-14½ (U-1-1/2)

ness of unstayed flat heads, cover plates, blind flanges, etc., shall be calculated by the following formula:[1]

$$t = d\sqrt{\frac{C \times P}{S}}$$

where t = minimum required thickness of plate, in.,

d = diameter, or shortest span, measured as indicated in Fig. P-14½ (U-1-1/2), in.,

P = maximum allowable working pressure, lb per sq in.,

S = maximum allowable unit working stress, as given in Table P-14½ (U-3), lb per sq in.,

C = 0.162 for plates rigidly riveted or bolted to shells, flanges, or side plates, as shown in Fig. P-14½A (U-1-1/2A); and for integral flat heads as shown in Fig. P-14½B (U-1-1/2B) where the diameter does not exceed 24 in. and the ratio of thickness of the head to the diameter is at least equal to or greater than 0.05.

C = 0.25 for heads forged integral with or butt welded to shells or pipes as shown in Figs. P-14½ D and E (U-1-1/2D and E) where the corner radius on the inside is not less than 3 times the thickness of the flange immediately adjacent thereto.

C = 0.30 for flanged plates attached to shells or pipes by means of lap joints as shown in Fig. P-14½ C(U-1-1/2C) and where the corner radius on the inside is not less than 3 times the thickness of the flange immediately adjacent thereto.

C = 0.50 for plates fusion welded to the inside of vessels and otherwise meeting the requirements for the respective classes of fusion welded vessel, including stress-relieving when required for the vessel but omitting radiograph examination, and where the plate is welded for its entire thickness as shown in Fig. P-14½ F (U-1-1/2F) with a fillet weld having a throat not less than 1.25 times the thickness of shell or flat head, whichever is smaller.

$$C = 0.30 + \frac{1.40 \times W \times h_G}{H \times d}$$ for plates bolted to shells, flanges, or side plates, in such a manner that the setting of the bolts tends to dish the plate, and where the pressure is on the same side of the plate as the bolting flange, as shown in Figs. P-14½ G and H (U-1-1/2G and H)

where W = total bolt load, lb.

h_G = radial distance from the bolt circle diameter to the diameter d, in.

H = total hydrostatic and force on area bounded by the outside diameter of the gasket or contact surface, lb.

d = as defined above.

[1] This formula is designed to give safe results in so far as stress conditions are concerned. Greater thicknesses than indicated by this formula may be necessary in certain special cases. For example, in a bolted cover plate as shown in Fig. P-14½ F or G (U-1-1/2F or G), the deflection of the plate under pressure may relieve the pressure on the gasket sufficiently to result in leakage. A further tightening of the bolts will tend to correct this condition. Another example is that of a cover plate, as shown in Fig. P-14½ F or G (U-1-1/2F or G), bolted to the channel casting of a multiple-pass heat exchanger, where the cover plate makes the seal with the partitions in the channel casting separating the different passes. The deflection of the plate under bolt tension and/or pressure may be sufficient to break its contact with the partitions and short-circuit the various passes. A further tightening of the bolts will tend to aggravate this condition.

b Openings. Unreinforced openings in unstayed flat heads shall be designed in accordance with the rules given in Par. P-268*a* (U-59*a*) where $D = d$ and K = (thickness required by formula given above in (*a*)) ÷ (actual thickness of flat plate).

Reinforced openings in unstayed flat heads where the maximum diameter of the opening does not exceed 50 per cent of dimension d shall be designed as though the heads were a spherical head dished to a radius equal to the inside diameter of the vessel and the reinforcement calculated in accordance with the rules in Par. P-268*b* (U-59*b*).

Where the maximum diameter of an opening exceeds 50 per cent of dimension d, the flat plate shall be designed as a flange in accordance with the rules for bolted flanged connections given in Pars. U-1001 to U-1007, inclusive.

Unreinforced and reinforced openings in unstayed dished plates as described in (*b*) shall be governed by the same rules as given for openings in dished heads in Par. P-195 (U-36).

PAR. P-264. REVISE FIRST SENTENCE TO READ:

All boilers OR PARTS THEREOF must be provided with suitable manhole or handhole openings FOR EXAMINATION OR CLEANING, except special types where they are manifestly not needed.

PAR. P-286. MODIFY PROPOSED REVISION OF SECOND SENTENCE TO READ:

The dimensions of flanges subjected to boiler pressure shall conform to the American Standards as given in Tables A-5, A-6, A-7 and A-8 in the Appendix, subject to the restrictions of

Par. P-12*b*, except that the face of a safety valve flange and the face of a nozzle OR FITTING to which it is attached, may be flat without the raised face for pressures not exceeding 250 lb per sq in., but [shall have the raised face] for higher pressures SHALL HAVE FACINGS SIMILAR TO THOSE SHOWN IN FIG. A-9 AND OF DIMENSIONS GIVEN IN TABLE A-12[2] IN THE APPENDIX.

PAR. P-299. REVISED:

P-299. *Fittings.* The flanges of ALL VALVES AND pipe fittings shall conform to the American [Tentative] Standards given in TABLES A-5, A-6, A-7 AND A-8 IN the Appendix FOR THE MAXIMUM ALLOWABLE WORKING PRESSURE AND TEMPERATURE AND SUBJECT TO THE REQUIREMENTS OF PAR. P-12.

THE THICKNESS OF ALL FITTINGS OR VALVE BODIES SUBJECT TO PRESSURE SHALL NOT BE LESS THAN THAT REQUIRED BY THE AMERICAN STANDARD FOR THE CORRESPONDING MAXIMUM ALLOWABLE WORKING PRESSURE, TEMPERATURE, AND THE MATERIAL USED.

ALL VALVES AND FITTINGS SHALL BE EQUAL AT LEAST TO THE REQUIREMENTS OF THE AMERICAN STANDARD FOR 125 LB PER SQ IN., EXCEPT WHERE A HIGHER PRESSURE OR STEEL CONSTRUCTION IS SPECIFICALLY REQUIRED.

ALL VALVES AND [If the] fittings ON WATER LINES [are] below the water line [they] shall be EQUAL AT LEAST TO THE REQUIREMENTS OF THE AMERICAN STANDARDS FOR A PRESSURE 20 PER CENT IN EXCESS OF THE MAXIMUM ALLOWABLE WORKING PRESSURE EXCEPT THAT FOR PRESSURE OVER 100 LB PER SQ IN. THEY SHALL BE EQUAL AT LEAST TO THE REQUIREMENT OF THE AMERICAN STANDARDS FOR 250 LB PER SQ IN. [extra heavy].

TABLE A-10 PRESSURE-TEMPERATURE RATINGS FOR STEEL FLANGED FITTINGS AND COMPANION FLANGES

Service Temperatures F	—Pressures Given in American Standards for 750 F—					
	100	300	400	600	900	1500
	Service Pressures at Temperatures From 100 to 850 F					
100	230	500	670	1000	1500	2500
150	220	480	640	960	1440	2400
200	210	465	620	930	1395	2325
250	200	450	600	900	1350	2250
300	190	435	580	870	1305	2175
350	180	420	560	840	1260	2100
400	170	405	540	810	1215	2025
450	160	390	520	780	1170	1950
500	150	375	500	750	1125	1875
550	140	360	480	720	1060	1800
600	130	345	460	690	1035	1725
650	120	330	440	660	990	1650
700	110	315	420	630	945	1575
750	100	300	400	600	900	1500
800	85	250	325	500	750	1250
850	70	200	270	400	600	1000

All pressures are in pounds per square inch (gage).

IN ALL CASES THE SCHEDULED WORKING PRESSURE FOR STEEL FITTINGS MAY BE ADJUSTED TO THE ACTUAL MAXIMUM ALLOWABLE WORKING PRESSURE ACCORDING TO TABLE A-10 GIVEN IN THE APPENDIX.

[The face of the flange of a safety valve, as well as that of a safety valve nozzle, may be flat and without the raised face for pressures not exceeding 250 lb but shall have the raised face for higher pressures.]

Tables A-5, A-6, A-7, and A-8 do not apply to the flanges on the boiler side of steam nozzles, or to fittings designed as part of the boiler. The terminating flanges, however, shall be in accordance with THESE Tables [A-5, A-6, A-7, and A-8] EXCEPT THAT the number of bolts in a flange may be increased provided they are located on the standard bolt circle AND SYMMETRICALLY ARRANGED.

[2] This table will be identical with Table 5 of A.S.A. Standard B-16c—1932.

SCREWED FITTINGS OF CAST IRON OR MALLEABLE IRON CONFORMING TO THE REQUIREMENTS OF THE AMERICAN STANDARDS FOR 125, 150, AND 250 LB PRESSURE AS GIVEN IN TABLE A-11 IN THE APPENDIX MAY BE USED EXCEPT WHERE OTHERWISE SPECIFICALLY PROHIBITED OR WHERE FLANGED FITTINGS ARE SPECIFICALLY REQUIRED.

CAST OR FORGED STEEL SCREWED FITTINGS OR VALVES THAT ARE AT LEAST EQUAL TO THE STRENGTH REQUIREMENTS OF THE AMERICAN STANDARD FITTINGS WHICH WOULD OTHERWISE BE REQUIRED, MAY BE USED IN ALL CASES EXCEPT WHERE FLANGED FITTINGS ARE SPECIFICALLY REQUIRED.

COPPER OR BRASS, SCREWED OR FLANGED-TYPE FITTINGS OR VALVES MAY BE USED PROVIDED THEY ARE AT LEAST EQUAL TO THE STRENGTH REQUIREMENTS OF THE AMERICAN STANDARD CAST IRON FITTINGS, WHICH WOULD OTHERWISE BE REQUIRED. THEY SHALL NOT BE USED FOR TEMPERATURES OVER 406 F OR WHERE STEEL OR OTHER MATERIAL IS SPECIFICALLY REQUIRED. SCREWED TYPE FITTINGS SHALL NOT BE USED WHERE FLANGED TYPE ARE SPECIFIED.

TABLE A-11 MINIMUM METAL THICKNESS OF BODIES OF CAST IRON AND MALLEABLE IRON SCREWED FITTINGS

(The following Table is taken from Tentative American Standards B-16d—1927 and B-16c—1927)

Nominal Pipe Size In.	—Metal Thickness, In.— Cast Iron Screwed Fittings 125 Lb	250 Lb	Malleable Iron Screwed Fittings 150 Lb
1/8	...	..	0.090
1/4	0.110	0.18	0.095
3/8	0.120	0.18	0.100
1/2	0.130	1.20	0.105
3/4	0.155	0.23	0.120
1	0.170	0.28	0.134
1 1/4	0.185	0.33	0.145
1 1/2	0.200	0.35	0.155
2	0.220	0.39	0.173
2 1/2	0.240	0.43	0.210
3	0.260	0.48	0.231
3 1/2	0.280	0.52	0.248
4	0.310	0.56	0.265
5	0.380	0.66	0.300
6	0.430	0.74	0.336
8	0.550	0.90	0.403
10	0.690	1.08	...
12	0.800	1.24	...
14 O. D.	0.880	1.33	...
16 O. D.	1.000	1.50	...

All pressures are in pounds per square inch (gage).

PROPOSED RULES FOR BOLTED FLANGED CONNECTIONS

U-1001. *Scope* (1) Bolted flanged connections having the dimensions given in Tables A-5 and A-6 for the working pressures and temperatures designated therein should be used for connections to external piping and may be used for other flanged connections. Connections of sizes and/or working pressures within the range of Tables A-5 and A-6 may be designed by interpolation.

(2) Bolted flanged connections having dimensions other than those given in Tables A-5 and A-6, or interpolated therefrom, shall be designed in accordance with the rules given in Pars. U-1002 to U-1007, inclusive. These rules may be applied to flanges of any diameter and for any working pressure.

U-1002. *Materials.* (1) Alloy-steel bolting material shall be made in accordance with Specifications S-9 for Alloy-Steel Bolting Material for High-Temperature Service, of Section II of the Code.

(2) Carbon steel bolts shall be of material made in accordance with standard commercial practise. They may be used provided the working pressure does not exceed 160 lb per sq in., and/or the working temperature does not exceed 450 F.

(3) Bolts and studs shall be equipped with semi-finished nuts of at least American Standard heavy dimensions chamfered and trimmed as given in Table UA-1. If washers are used under nuts, they shall be of forged or rolled steel.

(4) All bolts and studs shall have American National Standard coarse screw threads, provided that bolts and studs $1^1/_8$ in. in diameter and larger shall have eight threads per inch. A stronger form of thread may be used.

(5) Bolts less than $^1/_2$ in. in diameter shall not be used.

Flange Material. (6) Flanges that are to be fusion welded shall be of good weldable quality and the carbon content of such material shall not exceed 0.35 per cent.

(7) Rolled or forged-steel flanges shall be of material made in accordance with Specifications S-8 for Forged or Rolled-Steel Pipe Flanges for High-Temperature Service, of Section II of the Code.

(8) Cast-steel flanges may be used provided the thickness does not exceed $4^1/_4$ in., and shall be of material made in accordance with Specifications S-12 for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service, of Section II of the Code.

(9) Flanges fabricated by welding, as shown in Fig. U-101D, shall be of material made in accordance with Specifications S-1 for Steel Boiler Plate, S-2 for Steel Plates of Flange and Firebox Qualities for Forge Welding, S-8 for Forged and Rolled-Steel Pipe Flanges, S-12 for Carbon-Steel Castings, S-25 for Open-Hearth Iron Plates of Flange Quality, of Section II of the Code.

U-1003. *Working Stresses.* The design working stresses in a bolted flanged connection shall not exceed the values given in Table U-$1^1/_2$. Bolt stresses shall be calculated on the area at the root of the thread.

TABLE U-$1^1/_2$ MAXIMUM ALLOWABLE DESIGN WORKING STRESSES FOR BOLTED FLANGED CONNECTIONS AT VARIOUS TEMPERATURES, IN LB PER SQ IN.

Maximum Temperature F	Flange Material: Minimum of specified range of the tensile strength of the material, lb per sq in. 45,000	50,000	55,000	60,000	70,000	Alloy Bolting Material[1]
700	10,650	11,850	13,050	14,200	16,600	14,200
750	9,450	10,500	11,550	12,600	14,700	12,600
800	8,100	9,000	9,900	10,800	12,600	10,800
850	6,750	7,500	8,250	9,000	10,500	9,000
900	5,400	6,000	6,600	7,200	8,400	7,200
950	4,050	4,500	4,950	5,400	6,300	5,400

This table applies to all plain carbon steel flange materials and alloy steel bolting materials for which specifications are given in the Code. Where the minimum tensile strength of the specified range or the temperature differs from those for which values are given in the table, the values of maximum allowable design working stress may be determined by interpolation.

[1] Carbon steel bolts may be used provided the working pressure does not exceed 160 lb per sq in. and/or the working temperature does not exceed 450 F, and provided the design working stress does not exceed 11,000 lb per sq in. (see Par. U-1002).

U-1004 (1) The bolting shall be designed to resist the hydrostatic end force and to maintain a predetermined compression on the contact surface of the joint.

(2) The hydrostatic end force H in pounds is the total force exerted by the working pressure upon the area bounded by the outside diameter of the contact surface.

(3) The force H_G in pounds to maintain the predetermined compression on the contact surface is the total force exerted by the required unit compression acting upon the area of the annular cross-section of the contact surface.

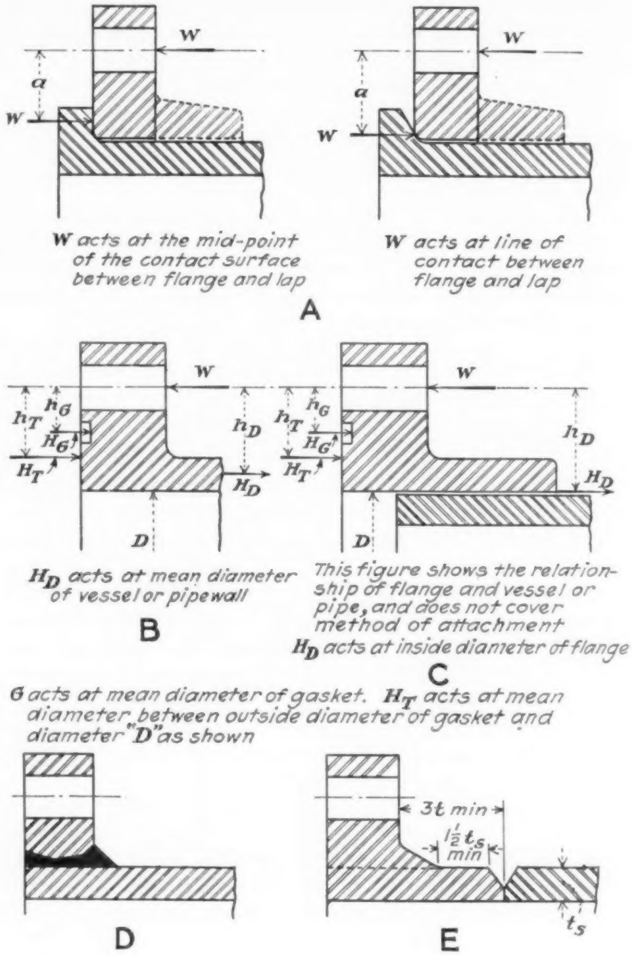


FIG. U-101

(4) The unit compression on the contact surface will be some multiple of the working pressure such as experience has shown will be sufficient to maintain a tight joint.[3]

U-1005 (1) For loose flanges, either with or without hubs, the lever arm a of the bolt loading shall be the radial distance from the bolt circle diameter to the line of pressure of the opposing force, as shown in Fig. U-101A.

(2) For flanges integral with the vessel or pipe, including those fabricated by fusion welding, of the type shown in Fig. U-101B and for flanges riveted, fusion-lapwelded or screwed to the vessel or pipe of the type shown in Fig. U-101C, the lever arm a shall be calculated by means of the following formula:

$$a = \frac{(H_D \times h_D) + (H_T \times h_T) + (H_G \times h_G)}{W}$$

where

H_D = end force due to hydrostatic pressure on area bounded by inside diameter D shown in Fig. U-101B and U-101C, lb

[3] The ratio of the unit compression on the contact surface to the working pressure (known as the contact-pressure ratio) depends upon the material and shape of gasket or ground face, the form of raised face or gasket groove, the nature of the confined fluid, and other similar considerations.

h_D = radial distance from the bolt circle diameter to the line of pressure of force H_D, in.
$H_T = (H - H_D)$, lb
H = total hydrostatic end force as defined above in Par. U-1004, lb
h_T = radial distance from the bolt circle diameter to the line of pressure of force H_T, in.
H_G = total gasket or contact load, lb
h_G = radial distance from the bolt circle diameter to the line of pressure of force H_G, in.
$W = (H_D + H_T + H_G)$ = total bolt load, lb.

(3) No consideration shall be given to any possible reduction in the lever arm a either due to cupping of the flanges or due to inward shifting of the line of action of the bolts as a result thereof.

U-1006 (1) The working stress in a flange, with or without hub, either loose, screwed, or attached to the vessel or pipe, or

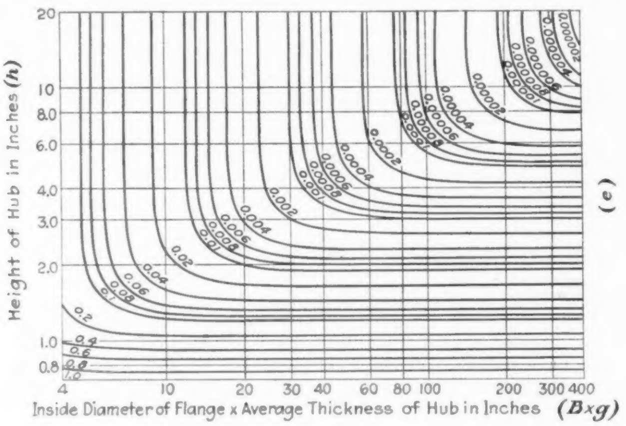


FIG. U-102

integral with the vessel or pipe, shall be determined by the following formula:[4,5]

$$S = \frac{0.955 \times W \times a \times (K+1)}{t^2 \times B \times (K-1)} \left[\frac{N}{\dfrac{10K}{K-1} + (B^2 \times t^3 \times e)} \right]^6$$

where

S = unit working stress, lb per sq in.
W = total bolt load, lb
a = lever arm distance, as defined in Par. U-1005, in.
t = flange thickness, in.
K = ratio A/B
A = outside diameter of flange, in.
B = inside diameter of flange, in.
e = value obtained from chart in Fig. U-102
g = average thickness of hub, in.
h = distance from back of flange to end of hub (height of hub), in.

$$\left.\begin{aligned} N &= 3 + (B^2 \times t^3 \times e) \\ &\text{or} \\ N &= \frac{10t^2}{g^2} \end{aligned}\right\} \text{whichever is greater}$$

(2) Flange thicknesses as used in the above formulas are to be the minimum thicknesses. Raised faces, grooves, or recesses, when required, shall be furnished as follows:

(a) No metal shall be cut from minimum flange thickness;

(b) The minimum flange thickness shall be first provided and then at least sufficient metal added thereto for the male or female, tongue or groove, raised face or recess;

(c) In Van Stone or lap joints, where the flanges have been recessed to receive the lap, the minimum flange thickness shall be measured from the thinnest portion of the flange.

(3) For hubbed flanges, the corner formed by the back of the flange and the hub shall be provided with a fillet, the radius of which in no case shall be less than one-fourth of the average thickness g of the hub, nor less than $^3/_{16}$ in.

U-1007 (1) Hubbed flanges may be attached to the ends of pressure vessel shells or nozzle necks by any of the methods permitted for circumferential joints in pressure vessels, and when so attached the attachment shall conform to the requirements for circumferential joints of the type employed.

(2) Ring flanges may be fusion welded to a cylindrical shell or nozzle neck as shown in Fig. U-101D provided that (1) the full depth of the flange is welded to the shell or neck, (2) for Class 1 vessels the welding meets the requirements for this class of vessel, with the exception of the radiograph examination, (3) for all other vessels the welding is stress relieved and meets the requirements for Class 2 vessels, and (4) the throat of the fillet back of the flange is not less than three-fourths of the thicknesses of the shell or nozzle neck.

(3) Flanges may be screwed or similarly attached to pressure vessels provided the attachment is sufficiently strong to resist the hydrostatic end force H_D with a factor of safety of 5.

(4) Hubbed flanges may be butt-welded to the end of a vessel or pipe provided that:

(a) The distance from the back of the flange to the center line of the weld is at least 3 times the thickness of the shell or pipe and not less than 1 in.;

(b) The hub of the flange at the beginning of chamfer shall have the same outside diameter and thickness as the shell or pipe to which it is to be butt-welded. The outside of the hub shall either be straight (parallel to the inside diameter), or tapered at not more than 6 deg for a distance at least $1^1/_2$ times the thickness of the shell measured from the beginning of chamfer.

TABLE UA-1 AMERICAN STANDARD HEAVY NUTS
(Semi-Finished and Hexagon)

Diameter of Bolt D		Width Across Flats Maximum (Basic)		Width Across Flats Min	Width Across Corners Min Hex	Thickness Heavy Nut Nom	Thickness Heavy Nut Max	Thickness Heavy Nut Min
$^1/_2$	0.5000	$^7/_8$	0.8750	0.850	0.969	$^{31}/_{64}$	0.504	0.464
$^9/_{16}$	0.5625	$^{15}/_{16}$	0.9375	0.906	1.033	$^{35}/_{64}$	0.568	0.526
$^5/_8$	0.6250	$1^1/_{16}$	1.0625	1.031	1.175	$^{39}/_{64}$	0.631	0.587
$^3/_4$	0.7500	$1^1/_4$	1.2500	1.213	1.383	$^{47}/_{64}$	0.758	0.710
$^7/_8$	0.8750	$1^7/_{16}$	1.4375	1.394	1.589	$^{55}/_{64}$	0.885	0.833
1	1.0000	$1^5/_8$	1.6250	1.575	1.796	$^{63}/_{64}$	1.012	0.956
$1^1/_8$	1.1250	$1^{13}/_{16}$	1.8125	1.756	2.002	$1^7/_{64}$	1.139	1.079
$1^1/_4$	1.2500	2	2.0000	1.938	2.209	$1^3/_{16}$	1.220	1.156
$1^3/_8$	1.3750	$2^3/_{16}$	2.1875	2.119	2.416	$1^5/_{16}$	1.347	1.279
$1^1/_2$	1.5000	$2^3/_8$	2.3750	2.300	2.622	$1^7/_{16}$	1.474	1.402
$1^5/_8$	1.6250	$2^9/_{16}$	2.5625	2.481	2.828	$1^9/_{16}$	1.601	1.525
$1^3/_4$	1.7500	$2^3/_4$	2.7500	2.663	3.036	$1^{11}/_{16}$	1.728	1.648
$1^7/_8$	1.8750	$2^{15}/_{16}$	2.9375	2.844	3.242	$1^{13}/_{16}$	1.855	1.771
2	2.0000	$3^1/_8$	3.1250	3.025	3.449	$1^{15}/_{16}$	1.984	1.894
$2^1/_4$	2.2500	$3^1/_2$	3.5000	3.388	3.862	$2^3/_{16}$	2.236	2.140
$2^1/_2$	2.5000	$3^7/_8$	3.8750	3.750	4.275	$2^{13}/_{32}$	2.458	2.354
$2^3/_4$	2.7500	$4^1/_4$	4.2500	4.113	4.689	$2^{21}/_{32}$	2.712	2.600
3	3.0000	$4^5/_8$	4.6250	4.475	5.102	$2^{29}/_{32}$	2.966	2.846
$3^1/_4$	3.2500	5	5.0000	4.838	5.515	$3^5/_{32}$	3.220	3.092
$3^1/_2$	3.5000	$5^3/_8$	5.3750	5.200	5.928	$3^{13}/_{32}$	3.474	3.338
$3^3/_4$	3.7500	$5^3/_4$	5.7500	5.563	6.342	$3^{21}/_{32}$	3.728	3.584
4	4.0000	$6^1/_8$	6.1250	5.925	6.755	$3^{29}/_{32}$	3.982	3.830

All dimensions given in inches.

[4] For loose flanges without hubs, the entire quantity within the brackets is equal to unity, and may be disregarded.

[5] The formula given in Par. U-1006 is an approximation of the Taylor-Waters formula and is deemed sufficiently accurate.

[6] Another simplified form of the Taylor-Waters formula is under consideration and may be obtained upon application.

BOOK REVIEWS AND LIBRARY NOTES

Stresses in Airplane Structures

The Stresses in Aeroplane Structures. By H. B. Howard. Pitman Publishing Corporation, New York, 1933. Cloth, $5^1/_2 \times 8^3/_4$ in., 264 pp., 155 figs., $5.

Reviewed by Alexander Klemin[1]

IN THE words of the author "the object of this book is to collect between one pair of covers those portions of the theory of structures which are of particular interest to the airplane designer. The development of the airplane has brought in its train considerable extension and amplification of the classical theory of structures. Much of this material is not readily accessible in textbook form. The present volume is an attempt to remedy this deficiency." The author has succeeded remarkably well.

For example, the first three chapters cover stress and strain, the bending of beams, columns of uniform sections, etc., in much the same manner that textbooks of the past have treated the same subject.

However, the chapters following extend and amplify these subjects to apply to the problems encountered in aircraft structures such as laterally loaded beams under axial loads; tapered struts; and continuous beams with end loads. Simply stiff frameworks, strain-energy theory, and redundant structures are treated carefully. Bow's notation, Maxwell's reciprocal theorem, and Castigliano's theorem are treated in detail.

Of particular interest to the aircraft constructor are the chapters dealing with torsion of circular and non-circular, as well as thin-walled, hollow shafts; also torsional instability of thin deep beams under thrust and torsion. There is also a very brief chapter on thin-walled sections dealing with flat plates as used in monocoque construction.

The author shows the use of graphical methods in determining bending moments of beams, laterally loaded under end loads, and with varying moments of inertia.

This book is not likely to go out of date since only the last three chapters, about 20 pages, cover the airplane specifically.

Richard Trevithick

Richard Trevithick: The Engineer and the Man. By H. W. Dickinson and Arthur Titley. The University Press, Cambridge, England, The Macmillan Company, New York, 1934. Cloth, $6^1/_4 \times 9^1/_2$ in., 290 pp., illus., $5.

WILLIAM McFEE, who has brought honor and distinction to the profession of engineering by his literary craftsmanship, says of a character in one of his novels that "he had discovered, early in life, that the world belongs to the enthusiast who keeps cool." This was one of the lessons, taught in a school of harsh experience, that Captain Richard Trevithick, civil engineer and pioneer of high-pressure steam, never learned, or, at least, if he did learn it, he failed to profit by it. For the tireless mental and physical energy of this incorrigible optimist drove him constantly into fresh adventures which previous bludgeonings of fickle fortune should have warned him against. He was, perhaps, your typical inventor, bursting with great ideas, most of which were practical; but he was doomed to financial failure and a poor man's grave through impracticality in matters of business. Greatly as he is remembered for his audacity in using steam pressures which even engineers still alive were wont to speak of as high, for cutting the coal consumption of contemporary steam pumping plants in Cornwall to one-third the formerly required amount, for the Cornish boiler, and for his steam locomotive, one cannot read his biography without feeling that what he lacked most tragically was direction and control which an astute and sympathetic business partner might have furnished. It is a pathetic circumstance that he should lie in an unmarked grave at Dartford, buried at the expense of his fellow workmen, and accorded by his contemporaries a single obituary notice of less than fifty words. Yet typical of his career it was, brilliant genius coupled with uncurbed optimism and enthusiasm, forever stumbling from achievement to frustration.

The picture of Richard Trevithick, as an engineer and as one of the most human of men, which H. W. Dickinson and Arthur Titley, president and past-president, respectively, of the Newcomen Society, have given us in this Trevithick Centenary Commemoration memorial volume, is convincingly lifelike. The affection and esteem in which a reader will hold this whirlwind of human energy grows mightily as his gigantic figure rushes through page after page of adventure, triumph, and disappointment, a man whose genius and virtues we must admire; and whose frailties we seek to condone.

Of the book itself and its arrangement and composition there is much which can be heartily commended. We are told that the authors, in anticipation of the Centenary of the death of Trevithick, and because of their long interest in his life, had set down much of their studies in writing, and that, when the Trevithick Centenary Commemoration Committee decided to publish a memorial volume, they offered their work for this purpose. The offer being accepted, difficulties of financing publication presented themselves, until the directors of Babcock and Wilcox, Limited, generously undertook to defray the cost. The result is an authoritative and thoroughly enjoyable biography.

The present reviewer finds much to admire in the design of the biography. In something more than four pages of the introductory chapter the reader may learn of Trevithick's accomplishments and the guiding principle of his life. This excites an intelligent curiosity about the man and his work and provides the dominant theme which persists throughout the succeeding chapters. The economic and engineering background of the Cornish mining industry, against which Trevithick's life was cast, admirably described in the second chapter, makes it easy to understand the factors that molded his early years and gives significance to the achievement of cutting to one-third the cost of unwatering the tin mines. In chronological sequence this romantic life is then unfolded, with enough technical description and illustration so that the engineer reader may form his own estimate of its engineering achievements. Quotations from contemporary letters add color and realism to the story, and extensive references to other works indicate the many sources from which material is drawn.

To the present reviewer, the account of the driving of the driftway beneath the River Thames seemed the most exciting

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incident of an exciting career. The authors, even though their story is largely told by means of quotations from contemporary letters, have succeeded in creating such a realistic picture that anxiety lest Captain Dick and his Cornish miners find themselves trapped by water and quicksand bursting into the narrow tunnel beneath the river's bed leads to rapid reading to find out how it all ended. And it ended, like so many other adventures, in hard work and getting nowhere.

Other technical points of excellence are the chronological table from which the important facts and dates of Trevithick's life may be picked at a glance, the list of patents, the bibliography, and the "pedigree" of the Trevithick family showing what a large number of the engineer's descendants have followed his profession.

Space will not permit comment on the multitude of thoughts that Trevithick's life inspires and that the authors have so skilfully raised in the reader's mind. But some of them are worthy of brief comment. First, there is the lifelong conflict between two great pioneers of the steam engine, Watt and Trevithick. Trevithick enters this conflict in two capacities, first, in attempting to break the Watt patent which the Cornish adventurers felt was causing them too heavy expenses in royalties, and second, in the rôle of a professional rival in a controversy over the use of high-pressure steam. His early skirmishes with the firm of Boulton and Watt seem to have left a lasting imprint on Trevithick. Even the South American interlude had its inception in the inability of Watt's low-pressure engine to operate economically at the high altitude of the Cerro de Pasco mines in Peru, giving Trevithick an opportunity to use his own engines which performed successfully under such conditions. And just before his death, in his petition to the British House of Commons for a reward for his inventions, Trevithick makes much of the saving to Cornish miners that his steam engines brought over the costs to operate Watt's engines.

Then there is that lifelong friendship with the scientist Davies Gilbert, sometime president of the Royal Society, to whom Trevithick turned when wishing advice or an opinion on matters beyond his knowledge. This unique combination of an audacious and prolific inventor and the clear-thinking and learned scientist needed only the genius of a business manager to make such an organization as might have served England and the world mightily in works of practical importance. A Matthew Boulton would have been able, perhaps, to train the childish impetuosity of the man who, because of his petulance over a matter of remuneration, deliberately allowed to sink back into the water the wreck he had raised, and who, gaining £2500 by salvaging tin and copper from a sunken frigate off the cost of Chile, "embarked the money in some Utopian scheme for pearl fishing at Panama, and lost all."

And finally, Jane Trevithick. "Marriage with Trevithick was no bed of roses," say the authors, "no ivy-clinging with such a whirlwind was possible." But she stuck magnificently to this wild inventor who was urged by the restlessness of his creative genius to think more of his schemes than of bread for his family. Eleven years of absence in South America with scarcely a letter and never a farthing, and tales of his infidelity, undoubtedly as false as they were malicious, could not shake her loyalty to him. Caring for him when he was at home, rearing his children, managing at times his accounts and affairs, she hovers in the background of his story as one who must have understood him and loved him, and for these reasons alone put up with his exasperating and impetuous ways.

There are two portraits of Trevithick in the book under review, one that of a boy, with dreamy, sensitive face that somewhat belies the reputation the lad had with his schoolmaster. The other shows him in the prime of life, a man of great physical strength, lips ready to speak or to smile, courageous, not stern. His right hand points over his shoulder to some mountains in the distance, perhaps the snow-capped peaks of Peru where he went, optimistic and enthusiastic, for the fortune that always eluded his grasp—the world he lost because he could not keep cool.

Such was Trevithick, one of the most romantic and fascinating of the pioneers of steam engineering. As an engineer and as a man his story will always appeal strongly to other engineers.—G. A. S.

Chrome Plating

Die Verchromung. By E. H. O. Bauer, H. Arndt, and W. Krause. M. Krayn, Technischer Verlag, G.M.B.H., Berlin. Paper, $6\frac{3}{4} \times 9\frac{1}{2}$, 256 pp., illus., 20 rm.; cloth, 22 rm.

This book deals with chrome plating with special regard to its application in the manufacture of automobiles and is of practical interest, because in addition to the description of processes of chrome plating, it deals in great detail with the methods of testing of metal plating generally and chrome plating in particular and covers such subjects as the general testing of metal plates. The characteristics of the exterior of metal plating (including such things as its light-reflecting capacity, adherence of metal plates to the base metal, and methods of testing it, hardness of metal plate, and its capacity to wear. One of the chapters discusses the effect of temperature on various kinds of metal plate with various kinds of base metal, porosity, tendency to corrosion, etc.

The final chapter contains a general survey of the subject of metal plating with particular regard to chrome plating.—L. C.

Books Received in the Library

Automobile-Engine Auxiliaries, Carbureters. By C. R. Strouse. International Textbook Co., Scranton, Pa., 1932. Leather, 5 × 8 in., diagrams, tables, $1.40. The first section describes the cooling systems of automobiles and the various thermostats, fans, radiators, and other devices connected with them. The second section discusses carburetors. The treatment is descriptive and in simple, practical language.

Die Berechnung der Trockendauer. By W. Fabricius. V.D.I. Verlag, Berlin, 1933. Paper, 6 × 8 in., 42 pp., illus., diagrams, charts, 2.50 rm. The investigation here reported was undertaken to throw light upon the factors which control the time required to dry materials. A formula was developed which will enable the designer of drying plants to determine the influence of each factor upon the drying process and so to design the most economical plant for any purpose.

Chemical Engineers' Handbook. (Chemical Engineering Series.) Edited by J. H. Perry and W. S. Calcott. McGraw-Hill Book Co., New York and London, 1934. Leather, 5 × 7 in., 2609 pp., diagrams, charts, tables, $9. This work, which is similar in form and make-up to the other engineering handbooks issued by its publisher, provides for chemical engineers a convenient, practical reference book which fills a decided need. Some sixty specialists have contributed to it. The field covered includes not only chemical engineering but also the important related fields. Special attention is given to cost data. Plant executives, mechanical engineers, and others engaged in manufacturing, in addition to chemical engineers, will find this a useful reference book.

Conjugate Functions for Engineers, a Simple Exposition of the Schwarz-Christoffel Transformation Applied to the Solution of Problems Involving Two-Dimensional Fields of Force and Flux. By M. Walker. Humphrey Milford, London; Oxford University Press, New York, 1933. Cloth, 6 × 10 in., 116 pp., diagrams, charts, tables, $4.75. A simple exposition of the Schwarz-Christoffel transformation, intended for engineers who have to deal with problems in hydrodynamics and aerodynamics, electrostatics, and electromagnetism. The subject is presented from the point of view of the engineer, rather than the mathematician, and developed through a number of typical practical examples.

COST AND PRODUCTION HANDBOOK. Edited by L. P. Alford. Ronald Press Co., New York, 1934. Leather, 5 × 8 in., 1544 pp., charts, diagrams, tables, $7.50. A reference work for industrial managers, which endeavors to provide, in one volume, all the information usually needed in the administration and operation of industrial concerns. Budgeting, factory organization, production planning and control, purchasing, storeskeeping, job standardization, rate setting, incentive plans, buildings and machinery, costs, cost accounting, depreciation, labor, and other topics are treated. Numerous authorities have assisted in preparing the book, which gives a satisfactory summary of current practise.

DEPRECIATION, a Review of Legal and Accounting Problems by the Staff of the Public Service Commission of Wisconsin. Submitted to the National Association of Railroad and Utilities Commissioners at its 45th Annual Convention in Cincinnati, Ohio, October 11, 1933. State Law Reporting Co., New York, 1933. Cloth and Paper, 6 × 9 in., 196 pp., charts, tables, paper, $1.50; cloth, $1.85. This report, prepared at the request of the National Association of Railroad and Utilities Commissioners, presents the view of the Wisconsin Public Service Commission as to the depreciation policy which should ultimately be adopted, and discusses some of the outstanding problems and legal principles that confront commissions. The meaning of depreciation, methods of accounting, depreciation as a factor in valuation, legal doctrines, depreciation reserves, and methods of estimating service life and depreciation reserve requirements are considered.

EASILY INTERPOLATED TRIGONOMETRIC TABLES WITH NON-INTERPOLATING LOGS, COLOGS, AND ANTILOGS. By F. W. Johnson. Simplified Series Publishing Co., San Francisco, 1933. Cloth, 7 × 10 in., tables, $3.50. The purpose of this book is to provide logarithmic tables that will be sufficiently accurate for ordinary calculations without any interpolation, and a set of trigonometric tables which can be interpolated more easily than others. The book contains both four-place and five-place tables of logarithms, cologarithms, and antilogarithms, five-place tables of natural and logarithmic trigonometric functions, and various other tables, with instructions.

EXPERIMENTELLE UNTERSUCHUNG DES FARBSPRITZVORGANGS. (Fachausschuss für Anstrichtechnik, Part 15.) By H. Grosse. V.D.I. Verlag, Berlin, 1934. Paper, 8 × 12 in., 18 pp., illus., diagrams, charts, tables, 3.50 rm. This report, which supplements a previous comparative study of guns for spraying paint, describes an attempt to determine qualitatively and quantitatively the factors that determine the quality of spray painting. The behavior of the paint in and directly behind the nozzle, in the air, and upon contact with the wall were studied by means of specially designed apparatus, and new light is thrown upon a number of fundamental matters.

FORTSCHRITTE IN DER NAHRUNGSMITTELINDUSTRIE. Berichte des Fachausschusses für die Forschung in der Lebensmittelindustrie beim Verein deutscher Ingenieure u. Verein deutscher Chemiker, Part 2. V.D.I. Verlag, Berlin, 1934. Paper, 12 × 8 in., 2.50 rm. The papers here assembled discuss the effect of temperature and humidity upon the color of meat, the cold consumption and water elimination in rapid and slow freezing of foods, the prevention of spoiling of food, modern developments in food preservation by refrigeration, and other topics relating to the food industry.

GREAT BRITAIN. Department of Scientific & Industrial Research. Food Investigation Special Report No. 43. His Majesty's Stationery Office, London, 1933. Paper, 6 × 10 in., 30 pp., charts, tables, 9d. (Obtainable from British Library of Information, New York, $0.22.) Discusses the changes that may occur in meat stored in butcher-shop refrigerators and points out the steps necessary to avoid spoiling of meat.

GREAT BRITAIN. Department of Scientific and Industrial Research. Fuel Research Technical Paper No. 39. VISCOSITY OF PITCH. By A. B. Manning. His Majesty's Stationery Office, London, 1933. Paper, 6 × 10 in., 20 pp., diagrams, charts, tables, 6d. (Obtainable from British Library of Information, New York, $0.17.) The investigation here described forms part of a study designed to correlate laboratory tests of pitch with its suitability for briquette making. The methods for determining viscosity are described, the viscosities of typical samples given, and the results of the determinations discussed.

GREAT BRITAIN. Department of Scientific and Industrial Research. Fuel Research. Physical and Chemical Survey of the National Coal Resources No. 29. AN INVESTIGATION OF THE ACCURACY OF ROUTINE ANALYTICAL DETERMINATIONS ON COAL AND COKE. By H. V. A. Briscoe, J. H. Jones, and C. B. Marston. His Majesty's Stationery Office, London, 1933. Paper, 6 × 10 in., 38 pp., tables, 9d. (Obtainable from British Library of Information, New York, $0.22.) This report presents the results of a careful study of the experimental errors to be expected in the analysis of coal and coke, a matter of considerable practical importance.

GREAT BRITAIN. Department of Scientific and Industrial Research. Report for the Year 1932–1933. His Majesty's Stationery Office, London, 1934. Paper, 6 × 10 in., 189 pp., tables, paper, 3s. (Obtainable from British Library of Information, New York, $0.88.) The work done by all the governmental research institutions and the licensed research associations is reviewed in this report, with lists of the publications that describe the results more fully.

HAUSHALT-KÄLTEMASCHINEN UND KLEINGEWERBLICHE KÜHLANLAGEN. By R. Plank and J. Kuprianoff. Second edition. J. Springer, Berlin, 1934. Cloth, 6 × 10 in., 182 pp., illus., diagrams, charts, tables, 13.20 rm. The development of mechanical refrigerators for domestic and shop use is described comprehensively, with full attention to American, as well as European practise. Details are given of the construction and method of working of the compressors, condensers, and other components of most of the systems of commercial importance.

HIGHER MATHEMATICS FOR ENGINEERS AND PHYSICISTS. By I. S. and E. S. Sokolnikoff. McGraw-Hill Book Co., New York and London, 1934. Cloth, 6 × 9 in., 482 pp., diagrams, tables, $4. The purpose of this book is to give students of engineering and other applied sciences a bird's-eye view of those topics of mathematics which are indispensable in the study of physical sciences, and thus to serve as a stepping-stone to advanced mathematical treatises.

INDUSTRIAL RADIOGRAPHY. By A. St. John and H. R. Isenburger. John Wiley & Sons, New York, 1934. Cloth, 6 × 9 in., 232 pp., illus., diagrams, charts, tables, $3.50. The general principles that govern the production and use of X-rays and gamma rays are set forth clearly, together with the special technique suitable for important classes of materials. The equipment required and the methods of using it, and the radiography of large castings and forgings, of welded structures, and of small objects are discussed in practical fashion. Costs are considered briefly. There is an extensive bibliography.

INGENIEUR UND VERBRAUCHSGÜTERTECHNIK. By S. Kiesskalt. V.D.I. Verlag, Berlin, 1934. Paper, 6 × 8 in., 28 pp., diagrams, tables, 1.80 rm. As the manufacture of prime movers and machine tools approaches the saturation point, mechanical engineers are shifting attention to the consumers' goods industries, particularly the chemical industry. In the present essay the author considers the changes in education that will best prepare future engineers for this new field and suggests steps that will bring these about.

INSTRUMENT FLYING, INSTRUCTION BOOK. By H. C. Stark. James Stark, Pawling, N. Y., 1934. Leather, 5 × 9 in., 77 pp., illus., diagrams, tables, $2. The first section of this book discusses in a practical way the problem and describes the necessary instruments and the proper way to arrange them in the plane. The second section contains a course of instruction in instrument flying which is concise, clear, and practical. The book is based upon personal experience as a pilot and as an instructor.

LIMITATIONS OF SCIENCE. By J. W. N. Sullivan. Viking Press, New York, 1933. Cloth, 6 × 9 in., 307 pp., $2.75. Only one chapter of this interesting work is concerned with the "limitations" of science. The remainder is concerned with its achievements and future objectives. The book affords a comprehensive, well-balanced picture of the whole field of scientific thought, admirably adapted to the needs of laymen who wish to learn what has been accomplished and what remains to be done.

OIL AND GAS BURNING UNDER BOILERS. By R. Little, F. B. Jones, and I. C. S. Staff. International Textbook Co., Scranton, Pa., 1933. Leather, 5 × 8 in., diagrams, charts, tables, $1.90. A concise, practical handbook, which gives details of equipment, methods of installing and operating, etc., in simple form.

PRINCIPLES OF AERODYNAMICS. By Max M. Munk. Published by author, 1734 Eye St., N. W., Washington, D. C., 1933. Cloth, 6 × 9 in., 252 pp., diagrams, charts, $1.75. This book contains, in revised and greatly enlarged form, the series of articles which Dr. Munk contributed to the *Aero Digest* two years ago. The book presents the principles of the subject in simple language, without any mathematical

detail, but care has been taken to insure scientific accuracy. It will, the author states, prove adequate for airplane designers whose interest is in the physical and practical aspects of aerodynamics.

TECHNOLOGIE DES ALUMINIUMS UND SEINER LEICHTLEGIERUNGEN. By A. von Zeerleder. Akademische Verlagsgesellschaft, Leipzig, 1934. Cloth and paper, 6 × 9 in., 289 pp., illus., diagrams, charts, tables, bound, 14 rm., paper, 12.60 rm. The author of this work, who has long been prominent in the Swiss aluminum industry, here discusses the uses of aluminum and its alloys from the point of view of the user. Casting, rolling, stamping and forging, brazing and riveting, cutting, surface treatment, heat treatment, and similar matters relating to aluminum are treated comprehensively. An extensive bibliography is included.

TEXTILES AND THE MICROSCOPE. By E. R. Schwarz. McGraw-Hill Book Co., New York and London, 1934. Cloth, 6 × 9 in., 329 pp., illus., diagrams, charts, tables, $4. A comprehensive manual on the use of the microscope in analyzing textiles. The equipment available is described, its advantages and limitations discussed, and directions are given for preparing specimens and analyzing fabrics, yarns, fibers, etc. Directions are clear and practical. A useful selected bibliography is included.

VALUATION AND REGULATION OF PUBLIC UTILITIES. By J. H. Gray and J. Levin. Harper & Brothers, New York and London, 1933. Cloth and paper, 5 × 8 in., 143 pp., paper, $0.75; cloth, $1. The reader who wishes to become acquainted with the general features of the problem of utility regulation will find this book a clear, concise outline of the subject. The history of regulation is briefly traced and the attempt at regulation by commissions is analyzed. The reasons why present methods have failed to meet public needs are discussed.

V.D.I. 71. HAUPTVERSAMMLUNG, FRIEDRICHSHAFEN/KONSTANZ, 1933. VORTRÄGE UND AUSSPRACHEN. V.D.I. Verlag, Berlin, 1933. Paper, 8 × 12 in., 157 pp., illus., diagrams, charts, tables, 3 rm. The papers presented at the 1933 meeting of the Society of German Engineers are presented here in a single volume, instead of being scattered through various periodicals, as in the past. These papers are grouped under several headings: Food and Housing, Welding, Flow, Light Construction, Civil Engineering, Steam Boilers, Textiles, Technology, and Economics. Under each topic are several papers by authorities.

WHAT'S GOING ON

A.S.M.E. Semi-Annual Meeting, Denver, Colo., June 25 to 28

THE Semi-Annual Meeting of the A.S.M.E. will be held in Denver, Colo., June 25 to 28, with headquarters at the Cosmopolitan Hotel. The meeting opens on Monday morning with two papers, one on passenger tramways and the other on smoke problems. The afternoon is given over to inspection trips.

PARTICIPATION BY BUREAU OF RECLAMATION

On Monday evening there will be a series of lectures with motion pictures giving a complete story of the remarkable work at Boulder Dam. Official participation by the United States Bureau of Reclamation has been authorized by Secretary of the Interior Harold L. Ickes. This participation will take the form of a presentation on "Reclamation Bureau Night" in the Broadway Theater, Denver, of a group of papers by Bureau engineers covering the developments at Boulder Dam together with several reels of moving pictures showing construction progress up to the moment. This meeting will provide an opportunity for engineers to obtain a comprehensive idea of the magnitude of this project, and of the problems encountered and the methods and means adopted to meet them. Dr. Elwood Mead, Commissioner of Reclamation, will be present and will discuss the activities of the Bureau and its relation to economic and social welfare in arid regions.

An opportunity will be provided engineers attending the Denver meeting to become acquainted with the facilities and personnel of this unique organization. The personnel of the Denver office of the Reclamation Bureau now comprises approximately six hundred engineers, designers, and draftsmen with the necessary clerical staff to handle the tremendous volume of business incident to such a concentration of designing, purchasing, and administration activities.

In connection with the design of the Boulder Dam studies on mass concrete were undertaken several years ago and laboratory facilities were established in two locations for concrete study, one in connection with such problems as heat rise, volume change, thermal conductivity, and specific heat of different mixtures of specific aggregates, and another for investigations of strength, elasticity, and permeability. The first laboratory has a unique equipment of chambers maintained electrically at constant temperature, and the second has chambers maintained at constant temperature and humidity for strength tests, together with a 4,000,000-lb hydraulic press for compression tests on large specimens. Original studies of aggregates and cements favorably located for various projects are carried on in connection with all new projects involving concrete design and construction, and routine testing in connection with all active projects is also handled from this point. In addition to these two laboratories located in Denver, which will be open for inspection during the A.S.M.E. meeting, the Bureau maintains a hydraulic laboratory in Denver and also a hydraulic laboratory at the Colorado State Agricultural College at Fort Collins, Colorado, about 75 miles north of Denver. In these laboratories hydraulic tests are made on scale models, and designs are perfected for spillways, siphons, and drops. At Colorado University, located in Boulder, about 35 miles from Denver, facilities are maintained for stress determinations and deformation on scale models of concrete dams and other structures. All of these laboratories and their equipment will be available for inspection by engineers attending the A.S.M.E. meeting.

In order to present some idea of the activities of the Reclamation Bureau as a whole, there will be presented on the foyer and mezzanine floors of the Cosmopolitan Hotel during the entire meeting, an exhibition of maps, plats, photographs, and architectural models arranged to show the details of each of the twenty-odd projects now actively in hand. Space has been assigned to each of these various projects and the information regarding each will be segregated and presented in such a way that individual analysis of each project will be possible. Representatives of the Bureau will be available for discussion of the features of these various projects with those interested.

TECHNICAL SESSIONS AND EXCURSIONS

Two simultaneous sessions will be held on the morning of the second day, one on heat engineering, covering air conditioning, experiences in the burning of pulverized lignite, and petroleum coke. The other session will be an informal round-table discussion arranged by the Management Division on the subject of the decentralization of industry, with particular reference to its effects in the West. A group of well-informed and interesting discussors is promised.

On Tuesday afternoon various plant inspection trips have been scheduled as well as another round-table discussion under the auspices of the Management Division, the topic for which will be the first year of industrial management under the NRA. Because of the interest already developed in this subject, the discussion promises to be unusually valuable.

A semi-formal banquet with an address by the President of the Society, Col. Paul Doty, and a very unusual address by Capt. Pat O'Hay is to be held on Tuesday evening. Dancing will follow the addresses.

The papers to be delivered on Wednesday morning will include an interesting discussion of beet-sugar manufacturing, mining in Colorado, and a description of a unique example of cooperative manufacturing. The papers at another session meeting simultaneously will cover recent progress of high-speed light-

weight railroad trains, with papers by representatives of the Burlington and the Union Pacific Lines. There is a possibility that the high-speed trains recently developed for these lines may be in Denver and available for inspection during the meeting. There will also be interesting sight-seeing trips and inspection tours.

A.S.M.E. National Petroleum Meeting at Tulsa

THE A.S.M.E. Petroleum Division will hold its 1934 national meeting at Tulsa, Okla., May 14 to 17, in connection with the International Petroleum Exposition. A program of 16 papers, dealing with problems of refining, production, and transportation, will be presented on three successive days. Headquarters will be the Club Room of the Tulsa Hotel. Inspection trips have been arranged to the Stanolind Pipe Line Company's Station at Hominy, Okla., to the Oklahoma City Field, and to the University of Oklahoma Experimental Laboratory.

Special reduced railroad fares will be available for this meeting. In purchasing your ticket, inquire of the agent.

Monday, May 14

9:30 a.m. ***Refining Session***

Retiring Thickness of Oil Refining Equipment, F. L. Newcomb, Standard Oil Development Co., Elizabeth, N. J.

Application of Fouling Factors in the Design of Heat Exchangers, E. N. Seider, Foster Wheeler Co., New York, N. Y.

Heat-Transfer Rates on Condensing, Reboiling, and Miscellaneous Heat Exchange Service, Max Higgins, The Texas Co., New York, N. Y.

Friction in Baffled Tube Bundles, T. F. Stack, Gulf Refinery Co., Port Arthur, Tex.

2:00 p.m. ***Refining Session***

The Use of A.S.T.M. Temperature-Viscosity Charts for the Blending of Lubricants, J. P. Calderwood, Kansas State College, Manhattan, Kan.

Petroleum Fuels and Combustion Data, O. F. Campbell, Sinclair Refining Co., E. Chicago, Ind.

The Design of Radiant Heat-Absorbing Section of Pipe Still Coils, Chas. E. McCulloch, Foster Wheeler Co., New York, N. Y.

Tuesday, May 15

9:00 a.m. ***Production Session***

Air-Gas Compressor Characteristics, J. P. Klep, University of Oklahoma, Norman, Okla.

Dynamometers for the Study of Pumping Problems, Blaine B. Westcott, Gulf Research Co., Pittsburgh, Pa.

2:00 p.m. ***Production Session***

Gas-Electric Prime Movers for Rotary Drilling, D. M. McCargar, Allis-Chalmers Co., Tulsa, Okla.

Oil-Field Rotary Pumps and Recent Developments, R. J. S. Piggott, Gulf Research Co., Pittsburgh, Pa.

An additional paper and informal discussion are planned for this session.

Excursion for Transportation Men. Inspection of Stanolind Pipe Line Company's Station at Hominy, Okla., leaving Hotel Tulsa at 1:30 p.m.

Wednesday, May 16

9:00 a.m. ***Transportation Session***

Selection of Economic Electric Motor Equipment for Pipe-Line Pumping Stations, W. H. Stueve, Oklahoma Gas & Electric Co., Oklahoma City, Okla.

Major Repairs of Diesel Engines, J. B. Harshman, Stanolind Pipe Line Co., Tulsa, Okla.

2:00 p.m. ***Transportation Session***

Fluid-Meter Research of Flow of Oil Through Orifices, Flow Nozzles, and Venturi Throats, W. H. Carson, University of Oklahoma, Norman, Okla.

Equivalent Lengths and Diameters, W. G. Heltzel, Stanolind Pipe Line Co., Tulsa, Okla.

Thursday, May 17

8:00 a.m. ***Inspection Trip***

Inspection trip of Oklahoma City Field and University of Oklahoma Experimental Engineering Laboratories, Norman, Okla. Leave from Hotel Tulsa.

Convention Tour to A.S.M.E. Semi-Annual Meeting at Denver

ARRANGEMENTS have been completed for special transportation for A.S.M.E. members and their friends who are planning to attend the Semi-Annual Meeting in Denver, Colo., June 25 to 28. The present plans call for departure from New York and other eastern points on Saturday, June 23, arriving in St. Louis the following morning. Both there and in Kansas City it is hoped that a large mid-western delegation will join the party. After the four days in Denver, the party will leave for a three-day tour of the Rocky Mountain National Park, returning to Denver to entrain for Chicago. At Chicago an opportunity will be afforded to visit the new "Century of Progress" Exposition, returning to eastern points not later than July 8.

The tour is arranged on the all-expense plan and includes round-trip railroad fare, Pullman, meals, and hotels—in fact all the necessary expenses with the exception of meals during the meeting and the meals, hotel, and other expenses, for whatever time is spent in Chicago. The total cost for the trip, as outlined, with lower berth from New York and return to New York will be approximately $150 per person, and from other points in proportion. This includes the lowest railroad rate ever offered for this type of travel to Denver via the St. Louis Gateway and returning via Chicago. There is also a possibility that a further slight reduction will be in effect on Pullman charges which, of course, would further reduce the price.

In addition all arrangements are flexible enough to permit stop-overs or to include additional side trips such as Boulder Dam and Colorado Springs, provided that these are made within the return time limit of the ticket. Write to A.S.M.E. headquarters, 29 West 39th St., New York, N. Y., outlining your desires, and a detailed itinerary will be submitted for approval.

A.S.M.E. Aero-Hydraulic Meeting, Berkeley, Calif., June 19 and 20

THE A.S.M.E. National Aeronautic and Hydraulic meeting will be held at the University of California, Berkeley, Calif., June 19 and 20, held under the auspices of the A.S.M.E. Aeronautic and Hydraulic Divisions. It has also been announced as an affiliated meeting with the American Association for the Advancement of Science, which is holding its meeting at the same time at the University. The Hydrology Division of the American Geophysical Union is also planning to cooperate in the A.S.M.E. meeting and to sponsor at least one session. The Society of Agricultural Engineers is considering a cooperative session dealing with the hydraulics of agriculture. Charles Lawrance, president of the Institute of the Aeronautical Sciences, is also planning to cooperate in the Aeronautic program and has appointed Dr. C. B. Millikan and Prof. B. M. Woods representatives of the Institute. Several local groups are also planning to cooperate in the meeting.

Oil and Gasoline Separators To Be Standardized

ON March 20, 1934, a committee was organized in New York to establish an American Standard for oil and gasoline separators for installation in the drains of garages and other buildings where there is a chance that these materials may enter the sewer connections. Those attending the meeting represented the manufacturers of these devices, the consumers, and municipal bureaus.

The new committee is to be designated as Subcommittee No. 9 of the Sectional Committee on the Standardization of Plumbing Equipment, William C. Groeniger, chairman. The latter was formed in 1928 under the procedure of the American Standards Association with the American Society of Sanitary Engineering and The American Society of Mechanical Engineers as joint sponsors. The recommendation for the organization of Subcommittee No. 9 came from Subcommittee No. 5 on the Standardization of Traps of which A. R. McGonegal is Chairman.

Joseph J. Crotty, President, American Society of Sanitary Engineering, presided at this first meeting and was elected permanent chairman of the subcommittee. Mr. Gerhard Wagner was selected as its secretary. Since the personnel of the subcommittee is still in-

complete the list of its members will be announced later.

The preparation of a standard for grease separators is included within the scope of this subcommittee's activity but the committee decided to give its attention first to the setting up of standards of performance for oil and gasoline separators. The importance of correct design and the satisfactory performance of these separators to public safety and to the elimination of property damage is well known.

A.S.M.E. Oil and Gas Power Meeting, June 20 to 23

THE Oil and Gas Power meeting is to be held at Pennsylvania State College, State College, Pa., June 20 to 23, inclusive. There will be five technical sessions devoted to the following subjects: Oil-field practise in power-driven machines, high-speed-engine design, fuel engine pumps, fuel-oil specifications, and the Diesel cost report, together with papers on the same subject. An interesting non-technical program has been planned including a banquet and a picnic. This year it is anticipated that the exhibit of the Diesel accessories will be even broader in scope than they were last year. All plans point to a successful meeting.

Cooperation Between A.S.A. and Bureau of Standards

THROUGH cooperation between the Department of Commerce and the American Standards Association further progress is being made in the development of a unified national standardization program in a single movement equally representative of Government, industry, and the general public. The Government will encourage the extension of the work of the Association and the utilization of its services by industries and groups desiring to establish standards. Meanwhile, it is realized that the facilities, experience, and contacts of the Bureau of Standards are valuable in the continuation of work on simplification and commercial standards. In order to utilize these values this new plan provides for cooperation between the Bureau, on its reduced basis, and the A.S.A. The latter, on behalf of industry and its consumer and general-interest groups, is increasing its share in the activities and responsibilities for this work.

For the present, and in the absence of conditions which may call for special handling, simplified practise and commercial standards projects will be handled in accordance with the following plan as regular procedure:

(1) A request to the A.S.A. or to the Bureau of Standards is made by an outside group for assistance in the development of a simplification or a commercial standard.

(2) The recipient organization notifies the other, with a copy of the request.

(3) The scope of the project is outlined, and special problems of handling considered by conference of the two staffs. To facilitate administration of the work each organization will supervise the projects accepted by it. Each organization will currently advise the other on each significant development.

(4) The project is assigned to a project man.

(5) A steering group is organized by project man.

(6) The draft standard is prepared or reviewed by steering group, contact being made with laboratory groups by Bureau staff. (Where research is necessary, the results will be published separately.)

(7) The draft standard is sent by project man to organized groups having substantial interest, asking their active cooperation and announcing that plans are being made for a formal general conference.

(8) The steering group, prior to general conference, officially considers criticisms of draft standard.

(9) Invitations to general conference issued.

(10) General conference held. (Attended wherever possible by members of both staffs.)

(11) Draft standard as amended by conference circulated for written acceptance.

(12) Study of returns by both staffs and representative of steering group, and recommendations formulated.

(13) Recommendations transmitted.

(*a*) To the Director of the Bureau of Standards

(*b*) To the Standards Council of the A.S.A.

(14) Announcement of completion of project, and the effective date or dates.

(15) Publication:

(*a*) The standard will be published by the Bureau of Standards, or by the A.S.A., or by both.

(*b*) Normally, the standard, having full approval, will be issued as either: American Simplified Practise or American Commercial Standard, and the cover will bear the statement: "Approved by the American Standards Association and promulgated by the U. S. Department of Commerce and the Association."

A.S.T.M.-A.S.M.E. High-Temperature Test Program

THE Joint A.S.T.M.-A.S.M.E. Research Committee on Effect of Temperature on the Properties of Metals last year prepared tentative "codes of recommended practise" for the making of short-time high-temperature tensile tests, and long-time or "creep" tests. Adherence to the principles described in these codes bids fair to enable different laboratories to secure consistent and reliable results.

In order that such consistency may be demonstrated, and in order to aid laboratories in achieving consistency, there has been a demand for a "standard" material to use in cross-checking results from different laboratories. To meet this demand the joint committee is having prepared, through the courtesy of the Bethlehem Steel Corporation, a supply of 0.40-per cent carbon open-hearth steel, specially made, selected, annealed, and tested so that the supply is of an extreme degree of uniformity, and thus suitable for cross-checking or so-called "calibration bar" purposes.

The joint committee will supply this steel to those laboratories interested in finding out how well their short-time and/or creep tests agree with those from other laboratories. Such cooperating laboratories will agree to make the comparison creep tests at one temperature and load and for the length of time selected by the committee, and the short-time tests at a few selected temperatures, recording all the data required by the codes in order to show that at least the minimum precautions for accuracy required by the codes have been observed. Sufficient material for duplicate tests will be supplied if desired. The A.S.T.M., 260 S. Broad St., Philadelphia, Pa., can supply at nominal cost pads of forms for reporting data, which workers in this field will find convenient not only for this report, but for regular use.

The results will be summarized, and when enough data are in, published, each laboratory being designated only by a symbol.

It is expected that the degree of concordance that will be shown by such a comparison will greatly increase the confidence of engineers in the determinations of high-temperature properties of metals made with modern equipment and using up-to-date precautions for accuracy.

The committee would like to have a list of the laboratories equipped to make short and long-time high-temperature tests under code refinements and the number of creep units that come within the code requirement available in each laboratory. It is desired to list in this "census" both the private laboratories of firms handling only the work of those firms themselves and the research laboratories that can handle such tasks for those whose own research laboratories are not so equipped. It is desired that apparatus and methods being used for study of the possible future applicability to high-temperature investigations of so-called "accelerated" methods be also listed.

Such a "census" will give a mailing list for announcements of matters of interest that the joint committee may wish to call to the attention of such laboratories from time to time.

The question of a possible future investigation of the relationship of "accelerated" tests to the regular single-load, single-temperature, long-time test and of various methods of interpolation and extrapolation from creep data to other loads, other temperatures, and other times, on which question the committee recently asked for comment from the industries concerned with the use of metals and alloys at high temperatures, was discussed at its recent meeting (Mechanical Engineering, February, 1934, pp. 127–128). Further comment is desired before the committee makes definite plans. A full statement of this problem may be obtained from the Secretary of the Joint Committee, Mr. N. L. Mochel, Westinghouse Electric & Mfg. Co., Philadelphia, Pa.

Requests for the steel to be used as "calibration bars" for cross-checking purposes on short-time and creep tests with information on the amount required, as well as information for the "census" of high-temperature laboratories able to operate under the committee codes, should also be sent to Mr. Mochel.

Nominating Committee, A.S.M.E., To Hold Hearings

A SERIES of open hearings of the A.S.M.E. Nominating Committee will be held in the localities in which the members and alternates of the committee reside so that members of the Society may have adequate opportunity to recommend names of officers for the coming year. Any member wishing to make such recommendations should get in touch with the representative of his group. Members who are uncertain as to which group their local section belongs will find this information on page 10 of the 1933 Record and Index. The open hearings to be held are as follows:

GROUP I

Boston, Mass. Office of Willard E. Freeland, interviewer, 100 Summer St., Saturday morning, May 12 and 26.

Springfield, Mass. Willard E. Freeland, interviewer, Hotel Kimball, May 7, 9 a.m. to 2 p.m.

Providence, R. I. Willard E. Freeland, interviewer, Providence-Biltmore Hotel, May 21, 9 a.m. to 2 p.m.

Waterbury, Conn. W. K. Simpson, interviewer, Room 311, Waterbury National Bank Building, May 19, and June 2 and 9, 10 a.m. to 12 m.

Worcester, Hartford, New Haven, Bridgeport. Discussion groups may be arranged with Willard E. Freeland before June 9.

GROUP II

New York, N. Y. C. P. Bliss and David Moffat Myers, interviewers, A.S.M.E. headquarters, Room 1101, 29 West 39th Street, May 11 and 25 and June 8, 2 to 5 p.m.

GROUP III

Baltimore, Md. Prof. A. G. Christie, interviewer, Johns Hopkins University, dates set by telephone appointment.

Philadelphia, Pa. K. M. Irwin, interviewer, board room, Philadelphia Engineers Club, 1317 Spruce St., May 11 and 25, and June 8, 2 to 5 p.m.

Schenectady, N. Y. A. I. Lipetz, interviewer, Engineering Building, American Locomotive Co., Nott St., April 16, May 14 and 31, and June 13, 9 a.m. to 12 m.

GROUP IV

Raleigh, N. C. J. M. Foster, interviewer, Room 104, Page Hall, North Carolina State College, May 8, 9, and 10, 2 to 5 p.m.

Birmingham, Ala. J. M. Gilfillan, interviewer, 617 North 10th St., May 19 and 26, and June 2 and 9, 9 a.m. to 12 m.

GROUP V

Grand Rapids, Mich. L. A. Cornelius, interviewer, Wolverine Brass Works, will be available either through correspondence or personal interview.

Detroit, Mich. A. N. Goddard, interviewer, 12280 Burt Rd., May 21 and 22, and June 4 and 5, 2 to 5 p.m.

GROUP VI

Chicago, Ill. F. B. Orr, interviewer, 1136 Edison Building, 72 West Adams St., dates set by telephone appointment, Central 1536.

South Bend, Ind. C. C. Wilcox, interviewer, The Studebaker Corporation, May 15, 16, and 17, 2 to 5 p.m.

GROUP VII

Denver, Colo. F. H. Prouty, interviewer, Prouty Bros. Engineering Co., 10th Floor, Exchange Building, May 14, 21, and 28, 2 to 5 p.m.

A.S.M.E. Transactions for April, 1934

THE April issue of the Transactions of the A.S.M.E., which, under the new plan approved by Council at its December, 1933, meeting, will combine all of the sections previously issued independently, and which is being sent to every member in good standing now registered in any of the professional divisions, contains the following papers:

Zap Flaps and Ailerons (AER-56-5), by Temple N. Joyce

A Thermal Study of Available Steam-Power-Plant Heat Cycles (FSP-56-4), by G. A. Hendrickson and S. T. Vesselowsky

Problems of Modern Pump and Turbine Design (HYD-56-1), by Wilhelm Spannhake

Determination of Initial Stresses by Measuring the Deformations Around Drilled Holes (IS-56-2), by Josef Mathar

Report on Oil-Engine Power Cost for 1932 (OGP-56-1)

Candidates for Membership in the A.S.M.E.

THE applications of each of the candidates listed below is to be voted on after May 25, 1934, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member having comments or objections should write to the Secretary of the A.S.M.E. at once.

NEW APPLICATIONS

AUG, WILLIAM F., Fishkill, N. Y.
BEALS, RICHARD ODEN, Oak Park, Ill.
BODIE, BELIN VOORHEES, Baltimore, Md.
BRODER, CHARLES, New York, N. Y.
CAMPBELL, CHAS. A., Watertown, N. Y. (Rt.)
CAPONECCHI, JOSEPH A. B., Corapolis, Pa.
DE QUEIROZ, JOEL, Albuquerque, Angola, Ind.
D'IMOR, E. J., Memphis, Tenn.
DUTTON, FREDERICK O., JR., South Charleston, W. Va.
EASTON, WALLACE M., Montreal, Quebec, Canada
FERENZAK, GEORGE W., Corona, L. I., N. Y.
FOGLE, PHILIP A., Columbus, Ohio
GAYDOSH, JOHN H., Yonkers, N. Y.
GIBBAS, LINUS J., Cincinnati, Ohio
GUTHER, GEORGE W., Lynbrook, N. Y.
HARRISON, GEORGE G., Berkeley, Calif.
HICKMAN, H. B., Charleston, W. Va.
JAPPE, K. W., New York, N. Y. (Rt. & T.)
JOHNSON, CLARENCE A., New York, N. Y.
JOHNSON, HARLEY A., Oak Park, Ill.
KROPP, RUPERT F., Whitestone, L. I., N. Y.
LAUX, J. P., Bethlehem, Pa.
LEE, ROBERT JAMES, Philadelphia, Pa.
LONG, JOHN E., Chicago, Ill. (Rt. & T.)
MARDINI, PEDRO, Angola, Ind.
MATHEWS, H. M., Thomasville, Ga.
MCBERTY, DON R., Warren, Ohio
MCCORD, CLAUDE M., Memphis, Tenn.
MCWHORTER, JOHN P., Charleston, W. Va.
MICHAL, EDWIN B., Round Mountain, Nev.
MULLER, DANIEL L., Bellaire, L. I., N. Y.
MURRAY, MICHAEL P., Evergreen Park, Ill.
NIELSEN, CARL A., Malverne, L. I., N. Y.
RICKETTS, GRANTLEY B. S., New Orleans, La.
RIVE, LEWIS HOOPER, Hollis, L. I., N. Y.
RONAN, JOHN T., Vallejo, Calif.
SAUNDERS, EDWIN B., Stanford University, Calif.
VENANZI, JOSEPH M., Camden, N. J.
WAGNER, ARNO, Ozone Park, L. I., N. Y.
WATERS, VINCENT F., Middletown, Ohio
WRAY, HAROLD C., Wichita Falls, Tex.

CHANGE OF GRADING

Transfers from Associate-Member

POSEY, JAMES, Baltimore, Md.
SHODHAN, B. G., Ahmedabad 2, India

Transfers from Junior

BETTMAN, ROBERT, Hoboken, N. J.
BICKEL, HERMAN H., Saginaw, Mich.
BRIDGMAN, ROBERT R., Hamburg, N. Y.
CHICK, ALTON C., Providence, R. I.
EUDY, E. HARRISON, Cleveland, Ohio
FINDLATER, S., McKeesport, Pa.
FRAUENTHAL, HENRY L., Freeport, L. I., N. Y.
GONZALES, R. A., York, Pa.
HOUSTON, ALBERT J. R., Omaha, Nebr.
JENKS, S. M., Pittsburgh, Pa.
MARKUSH, EMERY U., New York, N. Y.
MCCARTHY, EDMUND, New York, N. Y.
MCCONNELL, MALCOLM R., Pittsburgh, Pa.
NEWELL, RANDALL L., Canton, Pa.
ROUCH, ERNEST A., Bangor, Pa.
SCHMID, ARTHUR C., Hohokus, N. J.

Recent Deaths

ADAMS, HAROLD F., January 30, 1934
BAYLEY, WILLIAM, February 4, 1934
CHAMBERLAIN, ADAMS B., January 22, 1934
DALE, ORTON G., February 16, 1934
DAVISON, CYRUS E., March 8, 1934
FLAGG, STANLEY G., JR., March 14, 1934
GEIER, FREDERICK A., March 27, 1934
GREEN, SAMUEL M., March 22, 1934
GREENWOOD, JOSEPH R., March 2, 1934
HARTNESS, JAMES, February 2, 1934
KAIGHN, HERBERT E., March 18, 1934
KEARNEY, EDWARD J., January 12, 1934
LEE, WILLIAM S., March 24, 1934
LYMAN, JAMES, March 29, 1934
MARSHALL, WILLIAM C., February 1, 1934
MERRICK, EDGAR H., January 21, 1934
MITCHELL, GUY K., January 15, 1934
MORETON, GEORGE W., March 2, 1934
MOUNT, WILLIAM D., February 28, 1934
MURRAY, HENRY H., February 28, 1934
PENFIELD, WALTER G., January 3, 1934
POTTER, WILLIAM B., January 15, 1934
REYNOLDS, MYRON B., January 27, 1934
STANTON, FREDERICK L., January 28, 1934
WHEELER, FRANK R., March 1, 1934
ZEH, EDMUND W., March 17, 1934